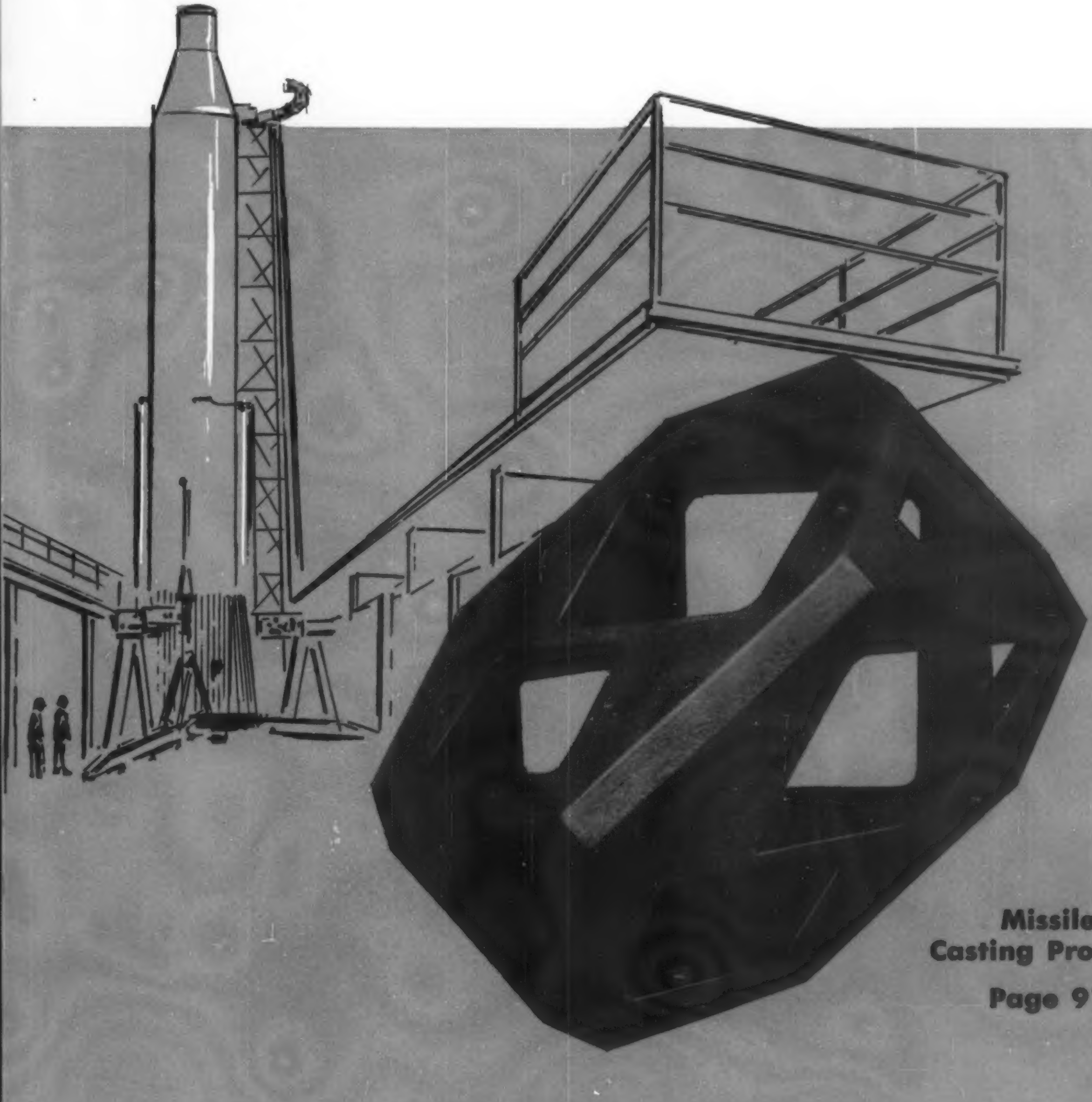
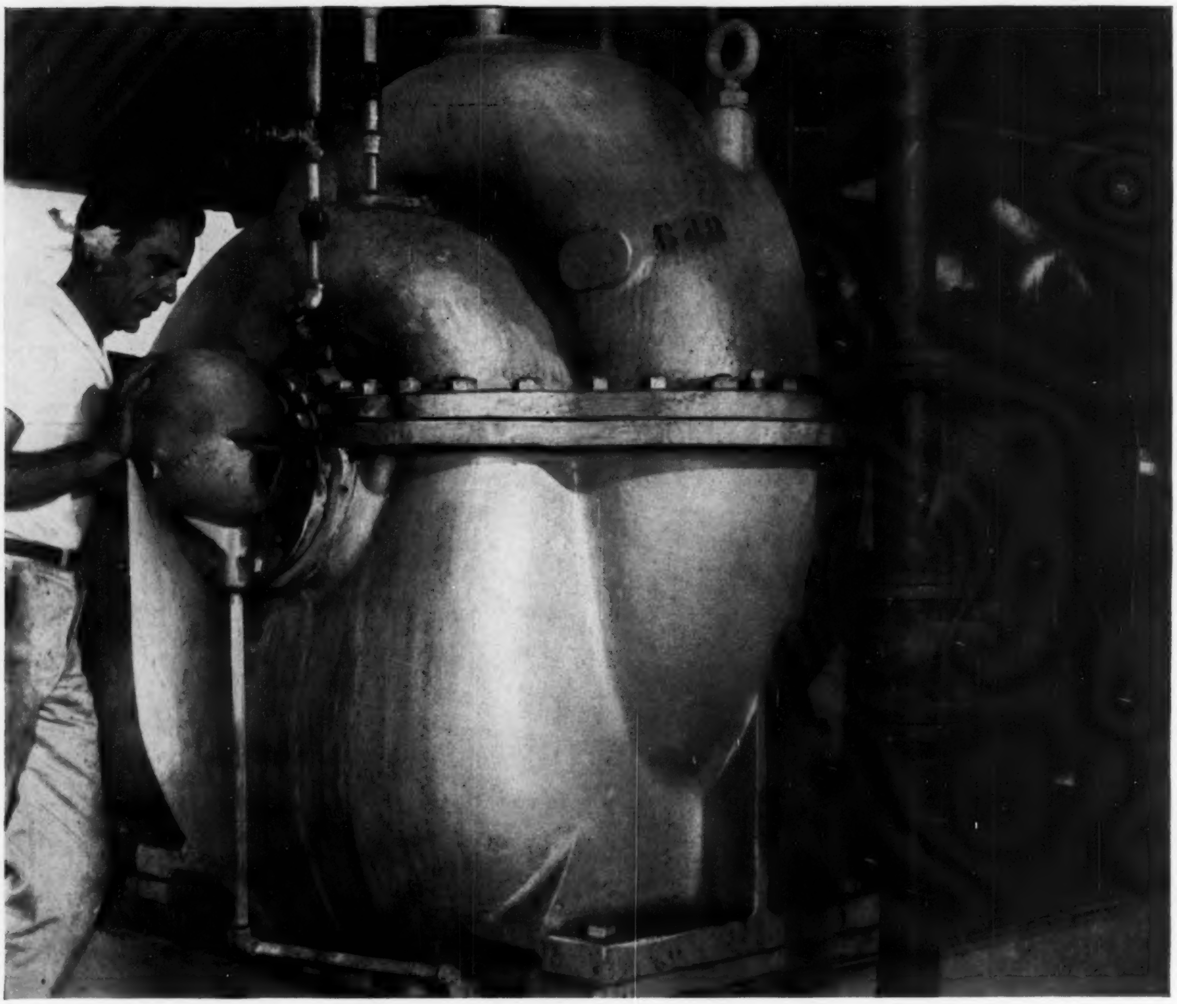


Missile Casting Progress

Page 91

modern castings

SEPTEMBER 1960



How a 2% nickel cast iron helped a foundry satisfy "the-man-in-the-middle"

The "man-in-the-middle" is really a composite; several officials of a typical Original Equipment Manufacturer, the C. H. Wheeler Manufacturing Co., makers of the pump shown above.

You know these men well; not by name, perhaps, but by the similarity of their needs to those of the men *you* have to satisfy with *your* castings.

One was *the pump's Designer*. He had the practical problem of laying out a casing that would conform to flow theory and still be castable. He was responsible, as well, for specifying an economical casting material that would provide adequate pressure tightness along with high resistance to wear, erosion and the corrosive attack of fast-moving seawater.

Wheeler's *Production Manager* was deeply concerned. He wanted the closest, as-cast, dimensional accuracy. Uniform metal structure and excellent machining properties, too.

The *General Manager* had still other considerations. What he was looking for was top production economy consistent with the high strength and stamina needed to insure freedom from trouble for Wheeler's customer, St. Regis Paper Company of Jacksonville, Fla.

With a 2% nickel cast iron, the foundry could satisfy easily all these diverse requirements. The use of Nickel in the composition gave them a high order of control over the irregular sections of the casting, providing uniformity of structure and soundness throughout.

With better control over such properties the foundry can, as in this instance, avoid many of the possible causes for reject.

If you produce cast iron, you will want to obtain an interesting summary of what the foundryman can offer Original Equipment Makers in nickel cast irons, and of how they can best be heat treated, machined, and welded. Send for our informative, 32-page booklet, "Engineering Properties and Applications of Nickel Cast Irons".

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N.Y.

INCO NICKEL

NICKEL MAKES CASTINGS PERFORM BETTER LONGER

September 1960 Vol. 38, No. 3

modern castings

world-wide technical authority of the metalcasting industry

MODERN CASTINGS is indexed by Engineering Index, Inc., 29 West 39th St., New York 18, N. Y. and microfilmed by University Microfilms, 313 N. First St., Ann Arbor, Mich.
The American Foundrymen's Society is not responsible for statements or opinions advanced by authors of papers or articles printed in its publication.
Published monthly by the American Foundrymen's Society, Inc., Golf & Wolf Roads, Des Plaines, Ill. Subscription price in the U.S., $5.00 per year; elsewhere, $7.50. Single copies 50¢. April, May and June issues $1.00. Entered as second-class mail at Pontiac, Ill. Additional entry at Des Plaines, Ill.

*PATENTS APPLIED FOR

"SUPER-STEEL"

STEEL SHOT *and* GRIT

$165.00

per ton
in truck loads

A revolutionary new process for producing steel shot makes it possible for METAL BLAST to offer substantial savings to *all plants using steel abrasives*. This new process turns out steel shot much more economically than the conventional process used by others — and savings are passed along to consumers!

"SUPER-STEEL" abrasives are strictly top quality and perform as top quality abrasives should — in cleaning action, in number of passes and effect on equipment. In fact, we'll give you a written, *money-back guarantee* that "SUPER-STEEL" will equal the performance of any steel abrasive now on the market.

Here's an opportunity to save many important dollars on steel abrasives. Why not at least investigate? Write, wire or phone (collect) for full information and sample.

METAL BLAST, INC.

873 EAST 67th STREET • CLEVELAND 3, OHIO • Phone: EXpress 1-4274

ALSO IN: Chattanooga . Chicago . Cincinnati . Dayton . Detroit . Elberton, Ga. . Grand Rapids . Greensboro, N. C. Houston . Los Angeles . Louisville . Milwaukee . Minneapolis . New York . Philadelphia . Pittsburgh and St. Louis.

MANUFACTURERS, ALSO, OF TOP QUALITY "SEMI-STEEL" SHOT AND GRIT, MALLEABLE AND CHILLED SHOT AND GRIT — AT COMPARABLE SAVINGS!

Circle No. 123, Page 147

modern castings

Golf and Wolf Rds., Des Plaines, Ill.
VAnderbilt 4-0181

Managing Director
Harold E. Green

Editor
Jack H. Schaum

Editorial Staff

George A. Mott, *News Editor*
Keith L. Potter, *Production Editor*

S. C. Massari, *Technology*
H. J. Weber, *Safety, Hygiene and Air Pollution Control*
R. E. Betterley, *Education*
H. F. Dietrich, *Industry*
C. R. McNeill, *Castings Congress Papers*
M. C. Hansen, *Castings Congress Papers*

Business Staff

Greta Maxfield, *Advertising Sales Liaison*

Mary McLean, *Advertising Production Manager*

Donna Pitkat, *Reader Service*

Mildred Michels, *Circulation Manager*

District Managers

Dwight Earley & Sons Co.—Midwest
221 N. LaSalle St., Chicago 1
CEntral 6-2184

C. A. Larson—Eastern
254 W. 31st St., New York
LOngacre 4-4285

Don Harway & Co.—Western
1709 W. Eighth St., Los Angeles
HUbbard 3-5141

John Ashcraft—European
67 Ave des Champs Elysees
Paris 8, France

Published by
American Foundrymen's Society

GENERAL MANAGER
WM. W. MALONEY

Let's look at...

PROFIT AND HUMAN WELFARE

TODAY IS NOT too soon to look again at two important phases of foundry operations: employee health and plant safety. The need to maintain hygienic conditions and control air pollution is self-evident in any foundry. Not so apparent is the need for a throughly planned accident prevention program.

Compared to similar metalworking fields, the foundry industry has one of the worst accident records of all. Yet one of the keys to profits is through adequate safety measures. Aside from the human values, which are all-important, many dollars can be saved through adequate safety programs.

This is why MODERN CASTINGS has increased the frequency of Herb Weber's column (see page 22). It now appears every month. This is the reason for such fine articles as you find on page 65 of our June issue. And this is the reason AFS has an expert, Mr. Weber, in the field working with plants, city and state governments, and health authorities. MODERN CASTINGS for three years straight (1956-57-58) received the National Safety Council's *Public Interest Award* for exceptional service to safety. It was the *only* magazine in the metalworking field to be honored.

Safety, hygiene, and air pollution control have a combined human welfare and profit meaning which should be taken to heart by every foundry operator. We, at MODERN CASTINGS, intend to promote in every way possible the values of such effort.

As a starter, we suggest: Why not re-examine your own plant's program?

Harold E. Green

Around the World with Modern Castings

AFRICA

Almost unlimited deposits of bauxite in close proximity to enormous hydroelectric potential mark Africa as the future supply center of the world for aluminum. Capital has been pouring into Guinea, Cameroon, Ghana, Congo Republic, Belgian Congo, and Angola from European and American aluminum firms. It's predicted that within three decades Africa may produce half the world's aluminum supply—*if* political stabilization can be achieved.

RUSSIA

Silicon may be the light metal of the future. Already reports from Russia tell of commercial silicon metal castings being used for corrosive applications at temperatures as high as 1110 F. Silicon has density of 2.33 compared with 2.70 for aluminum. It is one of the most abundant and widely distributed metals on the planet Earth—appearing naturally in the form of silica (SiO_2). Russians induction melt silicon and pour it into ceramic or graphite molds under an argon protective atmosphere. For a complete background report on the metal silicon read Walter Remmer's Hoyt Memorial Lecture, "Silicon: Present and Future," published in October 1958 MODERN CASTINGS.

SWITZERLAND

Low taxes and a central European location have encouraged more than 100 U.S. corporations in the last 18 months to establish overseas headquarters or subsidiaries in Switzerland. Included in the list are American Machine & Foundry Co., Union Carbide Corp., and DuPont Co. Another familiar name to the foundry industry with a Swiss branch is that of Lester B. Knight & Associates, Inc.

GERMANY

No country in the world can equal the extensive use that Germany makes of magnesium die castings. Volkswagen car production alone requires 50 tons of magnesium die castings daily! Metal is melted by electric induction furnaces and alloyed with 0.001 per cent beryllium. Besides lightweight, lowered machining costs are important reason for using magnesium die castings. The United States is currently experiencing considerable growth in the use of magnesium die castings.

ENGLAND

Redesign of parts so they can be cast is not just an American industrial sport, it is becoming an international game. In England, for instance, a cast magnesium 16-bladed cooling fan for cars has proven to have reduced wear on bearings and fan belt. Also farm tractors have been designed to use six 30-pound, permanent cast, magnesium track links on each wheel so they move along on continuous crawler tracks!

JAPAN

Technical assistance at the local level is being used by Japanese government to make its foundry industry more competitive. In Japan, each prefecture (a political subdivision of the country corresponding to a state) has a Technical Institute established to encourage and technically assist local industries, including foundry industry. Supported by local taxes, this industrial service provides trained consultants to help foundrymen solve their problems and improve their practices. Some

Around the World . . .

have training schools. At least one has portable x-ray equipment carried on a truck to foundries desiring casting inspection service. Engineers from these institutes come to the United States to study our metalcasting practices so that they can improve their local Japanese foundry operations. In the United States we have "county agents" to help farmers but no corollary assistance program for industry.

CANADA

Aluminum, Ltd. has just announced to its stockholders a new process for producing aluminum which could conceivably change the production pattern for the industry. Developed after years of research and expenditure of millions of dollars, the technique produces aluminum from bauxite without going through the usual stage of making alumina. A four million dollar plant capable of producing 6000 tons per year by the new process will be constructed at Arvida, Quebec. Substantial savings in certain production costs and investment required per ton of capacity are expected.

UNITED STATES

James B. Clow & Sons, Inc., prominent U. S. manufacturer of cast iron pipe, has just announced construction of a three million dollar cast iron pressure pipe plant in Melbourne, Australia. A joint venture with General Industries, Ltd., operations are scheduled for late in 1961. This is another example of the trend for American corporations to set up overseas affiliations to broaden their markets.

GERMANY

Steel foundrymen in Germany have improved on the conventional CO_2 process by adding clay and waterglass to the sand and omitting the CO_2 gas treatment. A mix of 140 parts sand, 5 parts bentonite, and 5 parts waterglass (48-50° Be) is molded the same as green sand. Molds and cores harden by CO_2 in the atmosphere. Surfaces are sprayed with 50 per cent waterglass solution 24 to 28 hours before pouring. Particularly suited to large molds and cores, the process is being used to make steel gear wheels, gear boxes and sprocket wheels.

RUSSIA

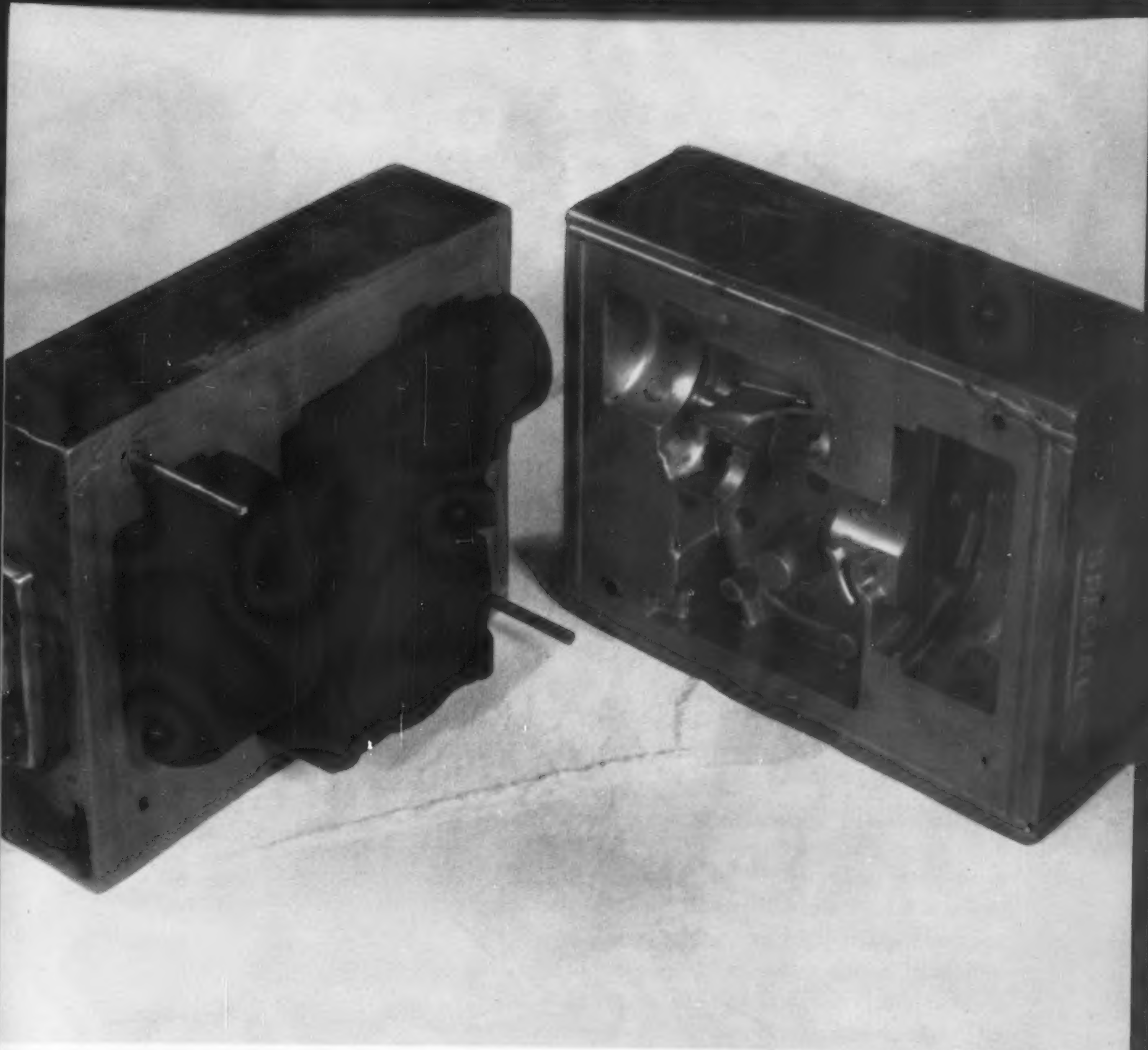
Russian foundrymen have discovered that they can stop oxidation of bronze with a limestone cover! Apparently the decomposition of the limestone at high temperature provides a carbonic acid cover which protects melt from oxygen. This practice may be the answer to expensive melting losses which constantly plague copper-base metal casters in the United States.

GERMANY

Reports from Germany emphasize the growing popularity of induction furnace melting for gray iron production. Ability to use sheet steel scrap and machine shop turnings or chips introduces sufficient savings to make induction melting competitive with cupola. Other plus factors are improved metal quality and operational flexibility.

HUNGARY

From the other side of the Iron Curtain comes a report of an interesting way to preheat the air being used for furnace combustion. Sand is tumbled from the top of chimney to the air intake chamber below the furnace. While dropping, sand first absorbs heat from rising flue gases, then transfers heat back to cold air entering system. Sand then is conveyed back to top of chimney to repeat the cycle. This novel heat transfer scheme reduces considerably the loss of furnace heat which normally occurs when cold air is pulled into the system.




VCA
Bob Bugg

Reader Opinions and Ideas . . .

GRAY IRON VS. ALUMINUM

We wish to congratulate the author and MODERN CASTINGS on the very fine article "Gray Iron vs. Aluminum."

It has been the writer's opinion for some time that if the suppliers of the gray iron industry and the industry itself worked together to publicize facts of the nature that appear in this article, we would be able to maintain and even improve our relative position in the field of metallic forms.

I plan to buy reprints of your article to distribute throughout the industry. Again, please accept my sincere congratulations for the best job I have seen done for the industry in many years.

H. H. MACLER, President
Drake Mfg. Co.
Friendship, N. Y.

HELP IN ALABAMA

I was very much pleased to see your MODERN CASTINGS article on the modernization of our Auburn foundry. We are hopeful that this foundry will make it possible for us to better serve the foundry industry of Alabama.

FRED H. PUMPHREY
Dean of Engineering
Auburn University
Auburn, Ala.

MORE TEAR SHEETS

Thanks very much for promptly sending the May and June copies of MODERN CASTINGS.

The tear sheets you recently sent covering CO_2 articles published in MODERN CASTINGS within the past few years will be most helpful. Until I had read the report from Britain I had not known of any large castings molded in CO_2 sands.

Your time and effort in searching out these articles is very much appreciated.

WM. M. EWING
Shenango Furnace Co.
Sharpsville, Pa.

GRAY IRON OPPORTUNITIES

The gray iron industry must continue to sell to engineers the fact that their product offers a wide range

of mechanical and physical properties that can be supplied in a minimum length of time.

Our foundry, for example, supplies the castings for a parent company producing a wide variety of power transmission, conveying, and material handling equipment. It is required daily to produce castings ranging from 30,000 psi to 50,000 psi, and in Brinell hardness ranges from 180 to 500. In addition to this there are requirements for chilled iron castings, heat resistant castings, and Ni-resist.

During the past few years we have been replacing other materials with iron castings. Also, due to better quality control methods, gray iron castings can be purchased with confidence.

C. W. Mooney, Jr.
Superintendent,
Olney Foundry Div.
Link Belt Co.
Philadelphia

ICI ABSTRACTS

I wonder if we could arrange to have Modern Castings sent to our new Technical Director, Cy Crawford, who is located at 27 Dogwood Drive in Summit, N. J.

Mr. Crawford has the responsibility for preparing future issues of the ICI Technical Review, which as you know, includes abstracts of articles of interest to our members. We certainly want him to receive copies of Modern Castings magazine, because they contain many articles of interest to our members.

Harry P. Dolan
Executive Director
Investment Casting Institute
Chicago

WATER-COOLED CUPOLAS

Ideas from Europe, as discussed in your June issue editorial, mentions water-cooled cupolas which caught my attention.

The water-cooled (jacketed) cupola concept was proposed first by Dr. Otto Gmelin, I believe of Budapest, around the turn of the century. A liningless cupola, except in the well section, it was tried, but operation was unsuccessful and the idea lost interest and impetus.

Since World War II, European foundries, principally because of low quality raw materials, have been forced to resort to basic operation. The high cost of basic type refractories rejuvenated interest and practice of water-cooled, thin lined, or liningless cupolas. Here's a case of

Continued on page 16

for an extra measure of
strength
it always pays to rely on
STERLING
EXTRA HEAVY DUTY
Foundry Flasks
Custom-engineered walls—for maximum rigidity—are designed to meet your specific requirements
Sterling never compromises the structural soundness of its flask designs. That's why you'll find heavier walls and strategically positioned reinforcements . . . skillfully engineered for maximum strength and rigidity. As a result, Sterling heavy duty flasks can shrug off the brutal beating of today's high-production foundry equipment.
Regardless of your foundry requirements, you'll get an extra margin of reliability in Sterling extra heavy duty flasks. This kind of engineered strength is an important reason for Sterling's undisputed leadership in the foundry flask field.
AO-4542
STERLING EXTRA HEAVY DUTY FLASKS HAVE OTHER QUALITY ADVANTAGES, TOO—
• Individually engineered
• Oversize flanges — extra thick, extra wide
• Flanges automatically precision welded to walls
• Accurately machined surfaces
• Jig-welded fittings
• Available with floor plate type walls if desired
• Stress relieved if desired
STERLING NATIONAL INDUSTRIES, INC.
Founded in 1904 as Sterling Wheelbarrow Co.
Milwaukee 14, Wisconsin, U.S.A.
Associate: STERLING FOUNDRY SPECIALTIES LTD.
LONDON • BEDFORD • JARROW-on-TYNE, ENGLAND
Sterling
WORLD WIDE SERVICE


"We don't
GARALD LAFOLLETTE, Coreroom Foreman,
BYRON JACKSON FOUNDRY DIVISION, BORG-WARNER CORPORATION Lawrenceburg, Indiana
"We're a young foundry building a reputation on our ability to produce impeller castings and other cast hydraulic components. We work with cored green sand and all-core molds. LINOIL assures smooth finish and close tolerances. We can't gamble on untried materials."
PAUL WILSON, Coreroom Foreman,
FRANK FOUNDRIES CORP., Muncie, Indiana
"I run the core room in the Muncie Foundry . . . turn out 60 tons of cores a day. They range from little ram-up jobs to 17-piece assemblies for transmission cases. It's a real headache if the core oil acts up . . . makes the difference between profit and loss. For a reliable oil . . . I'm sold on LINOIL."
JOHN WHITE, Core Foreman,
STRAIGHT LINE FOUNDRY & MACHINE COMPANY, Syracuse, New York
"We've mixed 5998 batches of LIN-O-SET bonded core sand and I've scrapped only thirteen! Some of our biggest cores take 22 batches. Our working time is 30 to 45 minutes."

Reader Opinions . .

Continued from page 12

economic conditions largely being the mother of invention, as is often the case.

Despite the tremendous interest in the subject of water-cooled and liningless cupolas, and the millions of words written and spoken about it, there are today in America relatively few foundries which economically require this. Quantitatively, *there are less than forty operating water-cooled, liningless cupolas in the United States* out of a total of about 3326 production cupolas.

The design and operational characteristics of water-cooled and liningless cupolas now are pretty well known and established, but their application and economic desirability should in each case be carefully studied.

C. McGlone, Manager
Cupola & Accessories Dept.
Whiting Corp.
Harvey, Ill.

FIRST AID FOR SAFETY

We would appreciate receiving six reprints of the article entitled Loss Prevention Through Accident Prevention, written by George A. Riley, and appearing in your June issue.

We found this article very inspiring. As we are now conducting an intensive safety program, we are sure that the members of our safety committee will be helped greatly by this article.

Elliott F. Metcalf,
Vice-President
Westmoreland Malleable Iron Co.
Westmoreland, N. Y.

INSURANCE RATES UNFAIR

The New York Fire Insurance Rating Organization has placed all aluminum producers in one single class of risk without giving any consideration to those producers who use no magnesium in connection with their operations. This is a very unfair rating system.

It is our belief, along with that of many others in the insurance business, that a separate classification should be created for those aluminum producers who do not use magnesium.

We would sincerely appreciate your cooperation in advising us as to whether or not this classification problem has ever been brought to the Society's attention. We would further appreciate, if you have such information available, knowing any other

Smart fellow — that Satan! He's found out our Koppers Premium Foundry Coke maintains a higher temperature range and keeps operating costs way down. Naturally he wants to order some.

But we wouldn't sell him. We sell only the *good* guys. We've found that once we have sold them — they *stay sold* and remain good customers of ours forever and ever.

The reasons are quite simple: Koppers Coke is prepared from the very best quality West Virginia coals, skillfully blended and baked the right length of time. It is absolutely uniform in *size, strength, structure* and *chemical analysis.* (We check each day's run to be sure.) And because of its superior physical qualities, its high carbon and low ash, Koppers Coke enables foundrymen to maintain higher temperatures which increases the cleanliness of the iron and helps cut fuel consumption.

Just for the devil of it, why don't you make your next order Koppers Premium Foundry Coke? It's available anywhere in the U. S. or Canada in sizes to fit your needs. Koppers Company, Inc., Pittsburgh, Pennsylvania.

Koppers Premium Foundry Coke

aluminum producers in the State of New York who do not use magnesium in connection with their operations. Such information will be most beneficial in strengthening our argument with the Rating Organization.

William R. Harris
Charles R. Daniels Agency, Inc.
Pawling, N. Y.

Editors Note: Here's your chance to do something about high insurance rates. If you operate an aluminum foundry in New York State and use no magnesium, send your name to Modern Castings. *Mr. Harris may be able to present a strong enough case to the Rating Organization so all will benefit from a lower risk rating.*

AIR SAMPLES

We have just had some dust counts made on air samples taken in various parts of our foundry.

Measurements	MPPCF*
Sample from breathing zone of a tableblast operator	2.1
Sample from breathing zone of a portable grinder	3.2
Sample from breathing zone of a molder operating squeeze molding machine	1.0
Sample from breathing zone of a coremaker in core room	0.8

**Million particles per cubic foot of air*

How would you evaluate these foundry conditions?

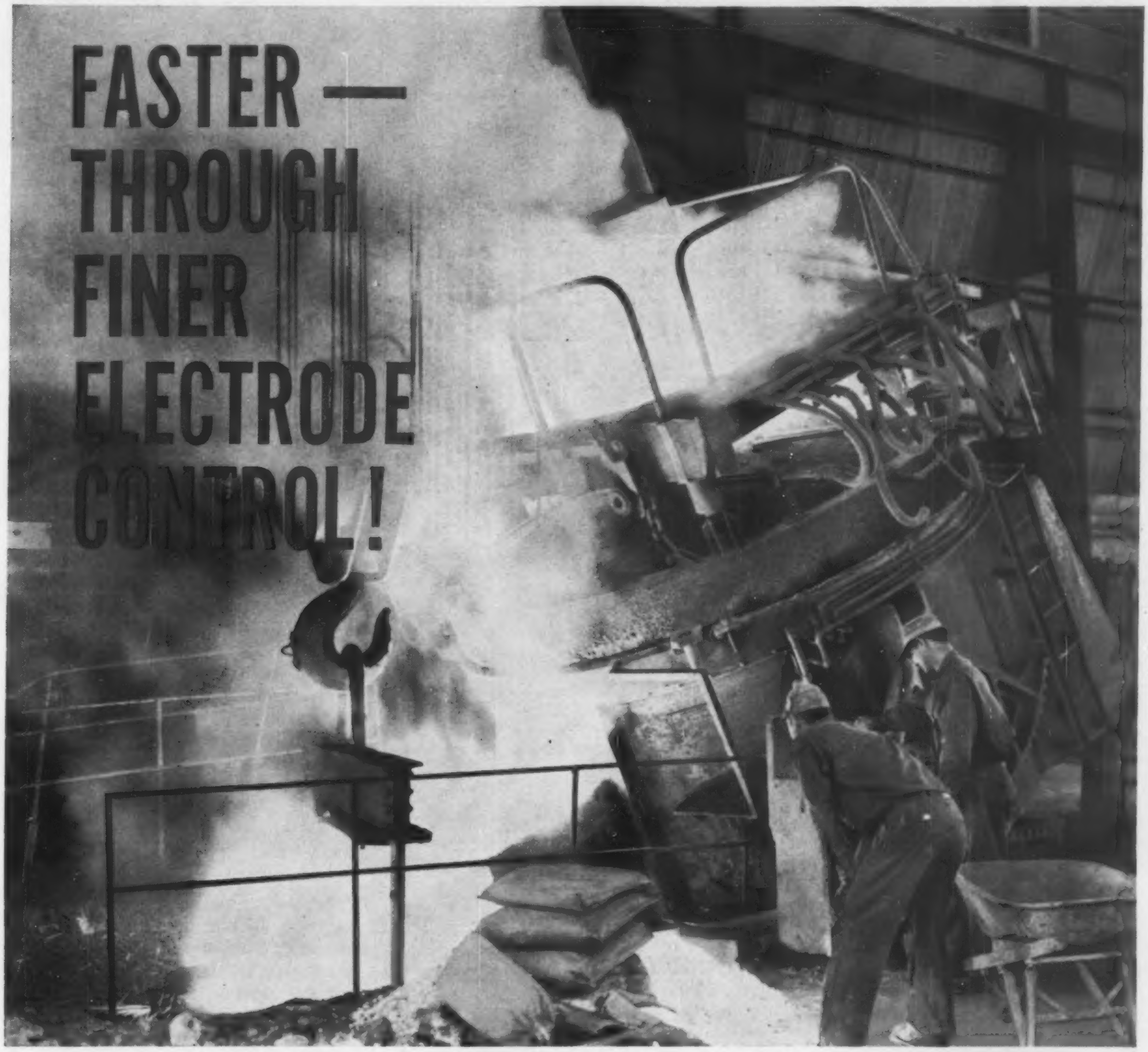
Clarence W. Rowsey
Director of Personnel & Safety
Hamilton Foundry, Inc.
Hamilton, Ohio

Note: The dust counts on the air samples taken in your foundry are exceptionally low and in most cases show no greater concentration of dust than one would find in outside urban air.

The maximal allowable concentration of dust is 5 MPPCF when the dust is composed of 100 per cent free silica. No foundry dust contains 100 per cent free silica since it is a mixture of metal particles, carbon, etc. Thus the maximal allowable concentration is much higher than 5 MPPCF.

The limit then is based on the dust count and the percentage of free silica. If the foundry dust contained only 20 per cent free silica—a fair average—you would be allowed a

FLORIDA STEEL CORP., TAMPA, SELECTS HYDRO-ARC ELECTRIC FURNACE FOR FLORIDA'S FIRST STEEL MILL!



Hydro-Arc electric furnaces, from Whiting, give you full-time arc efficiency, faster heats, more wattage turned into melt, lower electrode consumption, virtually no electrode breakage. Arc adjustment is instantaneous. Mechanical lag? Almost totally eliminated by non-stop, non-reversing electrode motors plus vital air counter-balance. Here's Whiting's new concept in low-cost electric melting—new, yet fully proven for your benefit in steel mill after steel mill. Look into Hydro-Arc now!

Get Details in Hydro-Arc Catalog No. FY-168, or ask a Whiting furnace engineer to call. No obligation. *Whiting Corporation, 15628 Lathrop Avenue, Harvey, Illinois.*

See Our Catalog in SWEET'S

FEMA

87 OF AMERICA'S "FIRST HUNDRED" CORPORATIONS ARE WHITING CUSTOMERS

ELECTRIC FURNACES

WHITING

MANUFACTURERS OF CRANES; TRAMBEAM® HANDLING SYSTEMS; PRESSUREGRIP; TRACKMOBILES®; FOUNDRY, RAILROAD, AND SWENSON CHEMICAL EQUIPMENT

Circle No. 134, Page 147

dust count of $\frac{5}{0.20} = 25$ *MPPCF without hazard.*

So I conclude that you not only have no hazard but you must have a very clean plant. HERBERT J. WEBER, Director, AFS Safety, Hygiene, and Air Pollution Control Program.

GRAY IRON MARKETS

Many of us at Hamilton Foundry read the MODERN CASTINGS' article, "15 Ways Your Gray Iron Business Can Grow." Here are a few more thoughts on the subject.

We feel there are many uses of gray iron castings and things that can be metallurgically done to gray iron to make it even more useful and salable.

The improvement of gray cast iron through heat treatment has long been recognized, but certainly never fully exploited to date. Hardening for increased strength and wear resistance; annealing for improved machinability; and stabilization for removal of casting stresses, offers great possibilities for improving upon the "as cast" properties.

In other words, the result is an extended range of properties and manufacturing economies available through these heat treatments and a broader opportunity for the sale of gray iron castings. These points must be brought to the attention of the casting consumer.

It is difficult to cite specific examples of improving gray iron's competitive standing, but in general we think that the various heat treatments of gray iron definitely and forcefully enhance this material.

PETER ROBERT RENTSCHLER
Vice President and Secretary
Hamilton Foundry Inc.
Hamilton, Ohio

Circle No. 135, Page 147

WIND TUNNEL

You may be interested in learning that we are preparing a wind tunnel study of air pollution conditions which are caused by smoke emission from a foundry. The plant in question is located here in Toronto. The relatively short cupola stack of this installation, and neighboring tall buildings prevent the smoke from clearing the ground sufficiently. Heavy, even dangerous pollution concentrations prevail most of the time in the immediate vicinity of the plant.

The obvious remedy is, of course, to raise the stack or the gas velocity so as to avoid entrappment of the smoke in the wake of chimney and buildings. The results of our wind tunnel investigation will eventually suggest this optimum stack height or gas exit velocity.

However, we are aware that there may be factors which are peculiar to the operation of a foundry and, in particular, to the nature of the emitted gas. So we would like to familiarize ourselves thoroughly with all aspects of the problem before making any recommendation to our client.

Since we understand that your organization takes a great interest in this issue we are hoping that you may be able to refer us to published information on similar situations and their solutions in the field of foundry technology.

G. ROSS LORD
Consulting Engineer
Toronto, Canada

Note: The American Foundrymen's Society has published a book, "Foundry Air Pollution Control Manual" which may be helpful in your problem. In my experience, when a plant is surrounded by other structures, collection equipment is usually required to abate a nuisance. HERBERT J. WEBER, Director, AFS Safety, Hygiene, and Air Pollution Control Program.

AIR POLLUTION CONTROL

by HERBERT J. WEBER

Here are nine operating procedures to reduce air-pollution emissions from foundry operations.

1. Maintain control over melting rate in order to obtain as near as possible a uniform rate of melting. This can be done by:
a) The installation of a holding ladle; or, if a holding ladle is already in use, by increasing its size. The steady melting rate thus made possible, reduces emission peaks.
b) The installation of an air-rate controller in order to maintain a uniform flow of combustion air through the cupola tuyeres. This eliminates pressure puffs which tend to increase the amount of emissions.
c) Uniform charging of the cupola, both in terms of accurate weight of charge components and in terms of uniform distribution of scrap in the charge. Other qualities of the scrap being equal, it is preferable to mix dirty scrap with clean scrap rather than to charge all dirty scrap on one day and all clean scrap on another.

2. Avoid rough handling of the cupola coke in order to reduce the amount of fines carried out of the stack. This may require:
a) Changing the method of adding coke to the charging bucket in order to reduce the distance the coke falls and to eliminate coke breakage. Where coke and metal are placed in the same bucket, the coke should be added last.
b) Screening or forking the coke or drilling holes in the chute bottom plates to drop out fines.
c) Keeping the cupola stock height as high as possible in order to keep the charges from breaking the coke. This also has the effect of preventing escape of combustible fines.

3. Use clean, well screened, unweathered limestone to minimize the amount of limestone dust discharged to atmosphere.

4. Briquette metal turnings and chips before charging. Chips may be charged with a device which injects them into the combustion zone of the cupola just above the tuyeres. Injection is accomplished by means of air pressure. This injector prevents loss of fine chips through the stack and reduces the emission of metallic fines which are sometimes a neighborhood nuisance and which may cause damage to the finish of automobiles.

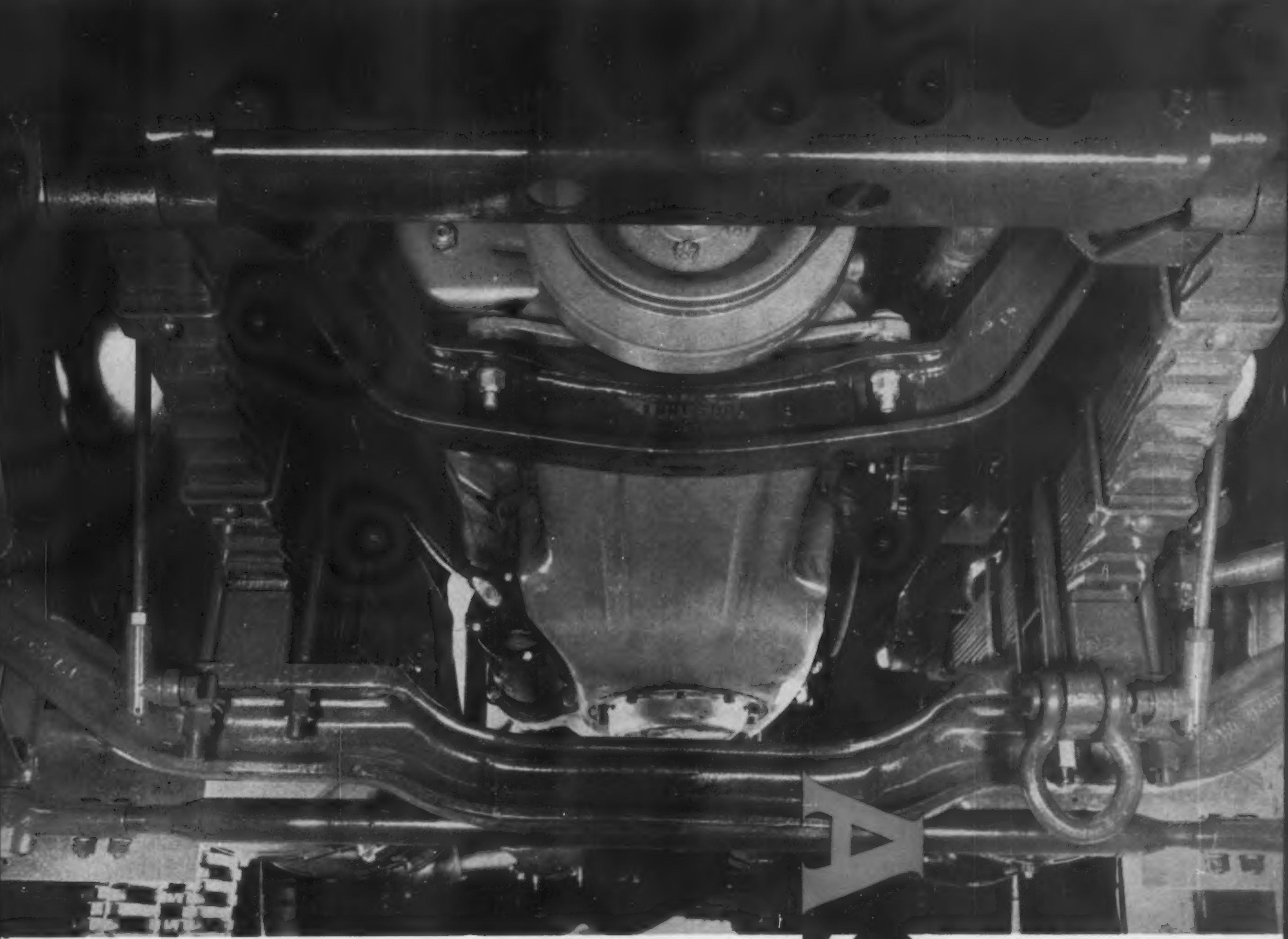
5. Clean greasy scrap before charging. This may require the installation of degreasing equipment or smokeless burn-off equipment. If economically practical, do not buy greasy scrap.

6. Use gas torches, oil burners or electric igniters rather than wood when lighting the cupola bed.

7. Install after burners at the charging-door level. These will consume unburnt gases and combustible particles when sufficient secondary air is available. After burners, however, will have no effect on metal oxides or fly ash.

8. When charging openings are too large, the effective draft of the cupola stack is reduced. This sometimes causes emissions to be discharged from the charging opening rather than from the top of the stack. This has the effect of:
a) Reducing stack-gas combustion time.
b) Emitting pollutants at a lower elevation thus losing any advantage of stack height.
c) Where mechanical charging equipment is used, the charging opening must be large enough to admit the charge buckets. If the size of such opening results in the conditions noted under item 8, then a sliding door —either the horizontal or vertical-movement type—may be installed.

9. Where the practice permits, gates, runners and risers should be cleaned with the casting. When these returns are then remelted, there will be a reduction in the silica fraction of the emissions.



Tenzaloy frame supporting front of heavy truck engine, is one of several truck engine parts now cast of Tenzaloy for high strength without weight.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

High yield strength at low cost:

TENZALOY

THE SELF-AGING ALUMINUM ALLOY

If your aluminum castings are too large or too intricate for heat treatment, if your heat treating facilities are limited, if you need high strength without costly heat-treating, specify "Tenzaloy"—developed by Federated to meet the need for a superior aluminum alloy that ages at room temperature. Tenzaloy eliminates rejects due to warpage, expansion, and internal stresses caused by quenching. Tenzaloy finished properties are stable, proved by conclusive test data over a ten year period. No special foundry techniques are required. No fluxes. Castability is excellent with sand, plaster molds and many permanent molds. Tenzaloy will not "grow," produces corrosion-resistant castings with excellent polishing characteristics and anodizes clear white. Write for TENZALOY Bulletin No. 103 to: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y. or call your nearest Federated sales office.

FEDERATED METALS DIVISION

Where to call for information:

ALTON, ILLINOIS
Alton: Howard 5-2511
St. Louis: Jackson 4-4040

BALTIMORE, MARYLAND
Orleans 5-2400

BIRMINGHAM, ALA.
Fairfax 2-1802

BOSTON 16, MASS.
Liberty 2-0797

CHICAGO, ILL. (WHITING)
Chicago: Essex 5-5000
Whiting: Whiting 826

CINCINNATI, OHIO
Cherry 1-1678

CLEVELAND, OHIO
Prospect 1-2175

DALLAS, TEXAS
Adams 5-5034

DETROIT 2, MICHIGAN
Trinity 1-5040

EL PASO, TEXAS
(Asarco Mercantile Co.)
3-1852

HOUSTON 29, TEXAS
Orchard 4-7611

LOS ANGELES 23, CALIF.
Angelus 8-4291

MILWAUKEE 10, WIS.
Hilltop 5-7430

MINNEAPOLIS, MINN.
Tuxedo 1-4109

NEWARK, NEW JERSEY
Newark: Mitchell 3-0500
New York: Digby 4-9460

PHILADELPHIA 3, PENNA.
Locust 7-5129

PITTSBURGH 24, PENNA.
Museum 2-2410

PORTLAND 9, OREGON
Capitol 7-1404

ROCHESTER 4, NEW YORK
Locust 5250

ST. LOUIS, MISSOURI
Jackson 4-4040

SALT LAKE CITY 1, UTAH
Empire 4-3601

SAN FRANCISCO 24, CALIF.
Atwater 2-3340

SEATTLE 4, WASHINGTON
Main 3-7160

WHITING, IND. (CHICAGO),
Whiting: Whiting 826
Chicago: Essex 5-5000

IN CANADA: Federated Metals Canada, Ltd.
Toronto, Ont., 1110 Birchmount Rd., Scarborough, Phone: Plymouth 73246

Montreal, P.Q., 1400 Norman St., Lachine, Phone: Melrose 7-3591

Circle No. 138, Page 147

MILEAGE FROM YOUR TRAINING DOLLAR

by Ralph Betterley

Outside training opportunities for key plant personnel have increased tremendously in recent years. Such courses have become a vital part of the training program of many companies . . . the foundry industry being no exception. The AFS Training and Research Institute has been such a program for the foundry industry.

Foundry management should carefully plan their participation in these courses if maximum value is to be received for money spent. With most authorities believing in the recognized value of outside training assistance, management can insure a better return on this manpower investment by thorough planning.

Ten points should be carefully considered when utilizing out-of-plant training courses. Listed, not necessarily in order of importance, they follow:

1. *Make course announcements and descriptions available to employees.* Many qualified and interested employees are not on course mailing lists. With good vertical communications between management and employees, prospective students having *desire* and *ability* can be located.

2. *The position, need, and use of courses should be clearly established in the foundry's over-all training program.* Courses should "fit in" with the company's training program and policy. Selection should not be made merely because it appears to be "a good thing to do", or that "you can't have too much training."

3 *Select the right courses.* Courses should fulfill specific needs of a plant's personnel in light of broad, long-range objectives. Needs may develop from a new process, equipment, products, department, or personnel. Fit the course to the man.

4. *Select the right time for course.* Dates of courses have to be considered with the foundry's schedules, production demands, vacations, expansion programs, and personnel in mind. Progressive foundries can effectively train when business is "slow".

5. *Select the right men for a specific course.* This should be carefully done with the level of the course being commensurate with the student's qualifications and needs. Indiscriminate personnel selection can be costly training or—in too many cases—no training at all.

6. *Prepare the candidates for the course.* Students should know what the course covers and what is expected of them. Advance study may be suggested. Post-course responsibilities should be indicated.

7. *Post-course application of information.* This is the "pay-off." Value can only be received if knowledge is applied. New techniques can be tried and implemented into the company's broad program. The returning "student" should be given responsibility and an opportunity to use information he has learned.

8. *Feed helpful information back to course sponsor to improve future instruction.* Management and student should make constructive suggestion for improvement of courses.

9. *Evaluate training benefits.* This is a difficult, slow, and intangible measurement in some cases. Conversely, however, in numerous instances specific personnel improvements, lower-cost operations, better quality castings, lower scrap, and solved problems have resulted from course participation.

10. *Up-grade personnel with training courses.* Outside course assistance for personnel development can become a workable means for up-grading purposes. Personnel selection hinges directly on this objective. Management should assume the responsibility of understanding the employee's future.

MAN VERSUS THE ELECTRONIC BRAIN

by H. F. DIETRICH

The development of electronics has certainly changed man's relationship toward man. Whether this is good, or bad, only time will tell. Looking at it from a production viewpoint, it seems that we can't get along without it. But from a humanitarian viewpoint, perhaps it would have been better if electronic control had never been developed.

This last statement should stir up quite a furor among electronic engineers, production control men, telephone operators, and statistical control experts. However, before you fellows brand me a heretic, allow me to make my position clear. I enjoy the things made possible by electronics.

Without the use of electricity, I would have to get to bed at a reasonable hour. It would have been impossible for me to work on a night shift—a valuable experience I will never forget. Without that prodigious waster of time, television, I would never know how they treat cats that get into Siberian pigeon lofts. If I couldn't watch the game-of-the-week, I would have to spend the afternoon fishing in the clean air instead of sitting in a soft chair, smoking more than is good for me. I'm sure there is a brighter side to this argument too, but for the moment, I can't see it.

We can't define electricity. Although we don't know what it is, this fundamental quantity of nature rules our lives. We have electronic-controlled molding lines. Our machine lines not only shape the casting but inspect them as well. A typewriter at one end of a copper wire can send out impulses that will operate similar machines all along a line. This displaces the typist who used to operate those machines—at least as far as her typing is concerned. Everything that man does with his hands can be expressed as a series of holes in an intricately punched card, or tape.

Now we have the electronic brain to determine whether a man is suitable for a job. Here is where I think we have given to the machine too much authority. By reducing the individual to the status of a number of holes in a punched card, we have lost the human contact so necessary in man's relationship with man. In spite of the studies made on personalities, no one yet has come up with a scientific answer to the reason one man can get along with a group, while another—who would look the same on a punched card—finds himself at odds with his fellow workers. This is a quality that can be determined only by human contact.

There was a certain satisfaction in the old fashioned interview of the foreman and the prospective worker. The foreman could learn about the man's experience, his family, his friends, his hobbies, and his temperament. To the foreman truely interested in hiring a man instead of a robot, a knowledge of these factors is necessary. As a result of such interviews, the foreman handpicked the crew with whom he could work in harmony.

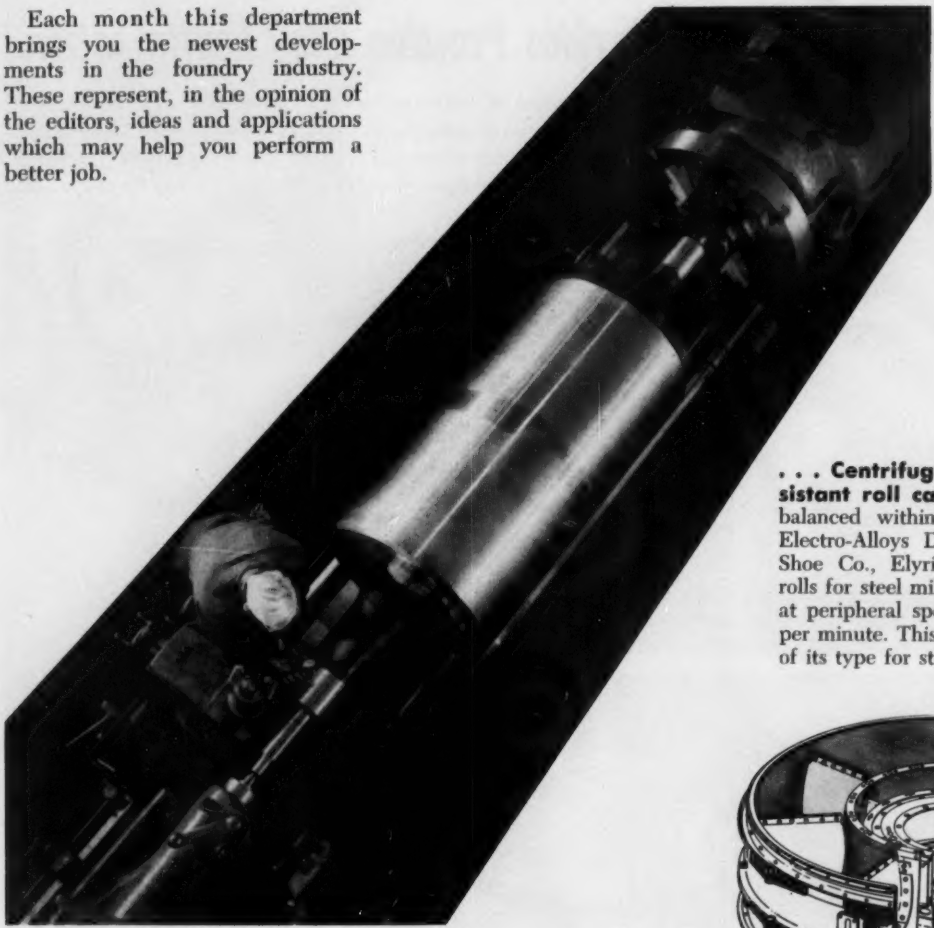
When the responsibility of hiring was shifted to the personnel manager, something of this human contact was lost. Some of the foreman's control of the man went with it. It is difficult for a foreman to exercise control of production when the control of employment is vested in some other individual. It is only natural that the worker's loyalty will be controlled by the authority to write the pink slip that terminates employment. Quite often the personnel manager has only a vague idea of the requirements of a good shakeout man or a dryfloor molder. Misplacement causes a turnover in personnel that can often be avoided if the foreman on the job interviews the man.

Today, we can throw a stack of cards into a vacuum separator which will classify them in any order we desire. Each of these cards represents the outline of a man. But will we find the right man for the job? The electronic brain lacks one thing—human contact. It cannot measure the complete man.

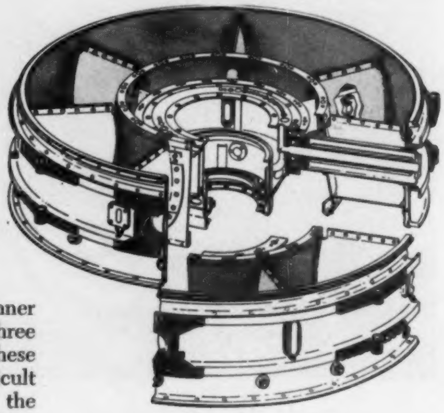
There is no hole punched in an IBM card for PERSONALITY.

Here's How . . .

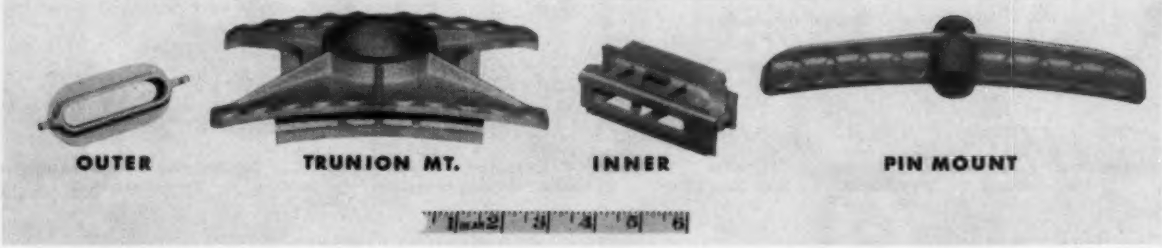
Each month this department brings you the newest developments in the foundry industry. These represent, in the opinion of the editors, ideas and applications which may help you perform a better job.



. . . Centrifugally cast, heat resistant roll casting is dynamically balanced within three ounce-inches. Electro-Alloys Div., American Brake Shoe Co., Elyria, Ohio, casts these rolls for steel mills to handle hot strip at peripheral speeds up to 2000 feet per minute. This casting is the largest of its type for strip annealing.



. . . Mono-shell investment castings serve as vital components of the turbine frame in General Electric's J79 jet engine. Misco Precision Casting Co., Whitehall, Mich., makes these castings by melting and pouring alloy A-286 into ceramic shell molds—all under vacuum! Each engine frame uses eight pin mounts, seven inner struts, seven outer struts, and three trunion mounts. The use of these structural type castings for difficult transition sections has increased the usable life for the jet engine turbine frame up to 800 per cent! Nice work, Misco.



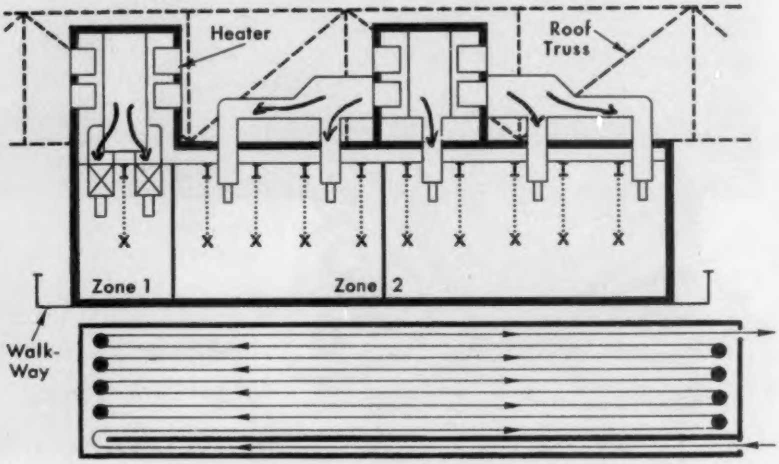
Here's How

Continued from page 28

. . . Shell cores are a natural for meeting the mass-production needs for soil pipe fittings. Here Milton Emery, production manager, Buffalo Pipe and Foundry Co., explains how these smooth, strong, and dimensionally accurate cores eliminate rough spots inside pipe fittings. Cores are blown with a mix of No. 70 gfn sand plus 3 per cent Durez phenolic resin. Stacked in tiers on the floor to heights of five feet is evidence of their ability to withstand rugged handling.

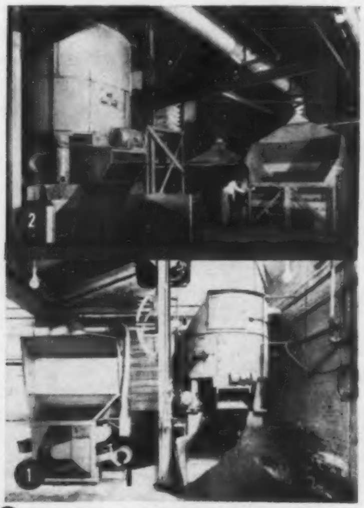
. . . To gain valuable floor space in a crowded foundry by hanging heat treat oven from plant trusses. The Aluminum Foundry Division of Chevrolet Motors in Massena, N. Y. used this trick to gain 4500 square feet of shop space. The oven is used to stress relieve aluminum cylinder heads, transmission cases, and engine blocks for Corvair cars. It is 150 feet long, 30 feet wide, and hangs 8 feet below the roof trusses.

Sketch shows how R. C. Mahon Co. designed and installed the aging oven. Top sketch is end view of the suspended oven; below is plan view indicating path of work travel on hook conveyor system. Note how oven nestles in roof trusses to provide head room for floor traffic.



. . . Ductile iron castings are used for precision tool room lathe parts by Pratt & Whitney Co. Machine tool builders take advantage of its machinability, wear resistance, strength, toughness, damping capacity, and stiffness. Because ductile iron has no size limitations, it is equally useful for parts ranging from small brackets and levers (see picture), weighing only ounces, up to massive components weighing over 20 tons.

Planned, Progressive Mechanization grows with you . . . costs you less



1. *Here's a start.* Mix-Muller, Loader, Screen-Master and exhausted hopper. Note magnetic separator.
2. *A step further.* Heavy duty shakeout screen is added.
3. *Next step . . .* elevator replaces loader and conveying equipment is added—still without major plant change or extensive pit or overhead work.

Here's an expandable sand conditioning and handling unit designed to increase your output at welcome savings in time and labor . . . without major expansion, plant change or big investment in mechanization.

If you have a Mix-Muller, you have a start! The simple addition of a National Screen-Master, Bucket Loader and Aerator can turn your mixing operation into a conditioning plant. A front end loader will get your sand up off the floor. As your mechanization needs grow, you'll find that National has the equipment and the know-how to help you grow efficiently, economically—to a predetermined Foundry-wise plan.

Why not let your NATIONAL representative show you, by your own records, how a National Utility Unit can pay its own way in as little as two years time?

WRITE FOR LITERATURE

NATIONAL ENGINEERING COMPANY
630 Machinery Hall Bldg.
Chicago 6, Illinois

F480

Circle No. 143, Page 147

EVERY little pig goes to Market

No little pig stays home—for some other purpose. The entire production of Interlake's famous Meltrite pig iron is for sale.

This means you can always count on Meltrite. It is in dependable supply at all times ...a key reason why foundries use more Meltrite than any other merchant pig iron.

CCC*

Wherever you are, a PM & Company Metallurgist is ready to talk with you about *"Controlled Cupola Charge" and how it can help you make better profits. Let us hear from you—no obligation.

MELTRITE

*** Controlled Cupola Charge**

PM

PICKANDS MATHER & CO.

CLEVELAND 14, OHIO

CHICAGO • CINCINNATI • DETROIT • DULUTH
ERIE • GREENSBORO • INDIANAPOLIS • NEW YORK
PITTSBURGH • ST. LOUIS • WASHINGTON

IRON ORE • PIG IRON • COAL • COKE • FERROALLOYS • LAKE FUELING • LAKE SHIPPING

Circle No. 144, Page 147

Brass and Bronze Industry Fights Way Back

A steady ten-year decline in demand for brass and bronze castings has forced this industry to take a close look at its past, present, and future. Here are four important areas covered in this critical self appraisal.

1. *What's wrong with brass and bronze casting business*
2. *How new technology is helping*
3. *New applications for copper-base castings*
4. *Improving today's competitive position.*

Also, Norman A. Birch reveals four new growth factors and six ways to create a "new look" for the industry. A special focus on what's ahead for the copper-base alloy foundries.

Reported by JACK H. SCHAUM

THE BRASS and bronze industry may be down, but don't count it out! In fact, it is very much on the rebound with a new awareness of its problems—and a lot of plans to fight its way back into a highly competitive position in tomorrow's markets. This is the substance of MODERN CASTINGS' latest "Market Opportunities" report. Realizing that the brass and bronze casting business has been ailing for some time, we asked key men in that industry just what was the trouble and what were they doing about it. The response was highly significant!

Catalyzed by catastrophe, the brass and bronze casting industry has been looking closely at itself, and doesn't like what it sees! Fortunately, this group has diagnosed its ailments with remarkable understanding, has selected the remedies, and is applying them with dogged determination.

A countdown on copper-base casting industry shortcomings in the past decade would include:

1. Customer dissatisfaction with inconsistent casting quality and poor service,
2. Purchase of inferior raw materials to save pennies when resulting scrap was losing dollars and customers,
3. Development of new alloys has been dormant—probably directly attributable to serious dearth of brass and bronze research,
4. Reluctance to accept and apply new foundry technology,
5. Poor communication between foundrymen and their customers. Failing to alert castings users of new capabilities of brass and bronze castings—a completely inadequate public relations and marketing effort,
6. Prejudice of design engineers against the use of castings,
7. Absence of economical and efficient means of testing and determining casting quality,
8. Too many castings scrapped because of dirt, blows, and pressure pockets,
9. Failure to keep foundries modernized with new equipment and processes,
10. Grossly deficient cost systems,
11. Foundrymen's lack of understanding alloys and their uses leads to unsuccessful applications and substitutions,
12. Contentment with producing the cheapest product possible,
13. Price instability compounded by "price wars,"
14. Aversion to participation in technical society committee activities and publishing of shop practices in journals.

These 14 negative counts against the industry largely account for the

THE CONTRIBUTORS

W. H. Baer
Engr., Research Dev. Lab., Fort Belvoir

A. R. Barbour
Roessing Bronze Co., Pittsburgh, Pa.

A. W. Bardeen
Ohio Brass Co., Mansfield, Ohio

Norman Birch
American Brake Shoe Co., National Bearing Div., St. Louis

C. R. Cairnie
Orrville Bronze & Aluminum Co., Orrville, Ohio

R. A. Colton
American Smelting & Refining Co., Houston

Jake Dee
Dee Brass Foundry, Inc., Houston

L. H. Durdin
Dixie Bronze Co., Birmingham

R. B. Fischer
Ingersoll-Rand Co., Phillipsburg, N. J.

J. C. Fox
Consultant, Toledo

J. F. Klement
Ampco Metals, Inc., Milwaukee

P. E. Lankford
East Birmingham Bronze Foundry, Birmingham

D. A. Mitchell
Progressive Brass Mfg. Co., Tulsa

A. J. Moore
Canadian Bronze Co., Ltd., Montreal, Canada

M. E. Nevins
Wisconsin Centrifugal Foundry, Inc., Waukesha, Wis.

F. L. Riddell
H. Kramer & Co., Chicago

Harry M. St. John
Consultant, Fort Pierce, Fla.

W. M. Spear
Worthington Corp., Harrison, N. J.

R. C. Stokes
Crown Non-Ferrous Foundry, Inc., Chester, Pa.

Alfred H. Hesse
R. Lavin & Sons, Inc., Chicago

poor showing made in the last 15 years. W. J. Grede demonstrated this dramatically in his 1960 Hoyt Memorial Lecture, "Where Do We Go From Here?" with the chart shown on page 37. Growth comparisons are made between the various metals (and also plastics). Average production (in tons or pounds) for the three-year period 1956-57-58 was compared with the average for 1946-47-48. Copper and copperbase alloy castings production shrank 19 per cent during this era—from an annual average of 1,059,300,000 pounds to 860,400,000 pounds!

Technology is Helping

The brass and bronze casters have not been completely by-passed in the technology explosion. Many of the progressive foundrymen have been building mechanization and automation into their plant operations. Because of the custom nature of their business, mass production techniques are not always feasible to incorporate.

New molding and coremaking techniques are benefiting brass and bronze casting as well as all other facets of the metalcasting industry. The CO_2 process, shell molding and coremaking, cold set binders, mold and core shooting and blowing, diaphragm molding, stack molding, and new green sand practices are permitting high-speed production of molds and cores with surfaces and tolerances never achieved.

The resulting castings have sufficient as-cast finish and dimensional accuracy to be machined in automatic high-speed machines or even be used as-is. The closer the piece is cast to finish size, the greater the ultimate savings in machining.

Recently announced were polystyrene plastic patterns that can be rammed up in the mold and do not have to be removed. Molten metal evaporates the pattern and fills the mold cavity vacated by the disappearing pattern.

Rapid melting reverberatory furnaces have been developed for high-speed production, low maintenance, and fuel economy. The trend of the future has already started with a wave of low-frequency induction furnace installations. These units permit close metallurgical control and remelting of turnings; melting losses and atmosphere contaminations are low.

New authoritative data on 16 mechanical and physical properties of three standard copper-base alloys (80-10-10, 85-5-5-5, and 88-6-2-4) have been amassed by Battelle Memorial Institute in a project sponsored by the Brass & Bronze Ingot Institute. Design engineers as well as foundrymen are now better informed on alloy selection.

Just announced at the 1960 AFS Castings Congress was a new modification of 70 Cu-30 Ni cupro-nickel. Addition of columbium and silicon plus heat treatment achieves remarkably improved mechanical properties and weldability.

Ship propellers are now being cast in a promising aluminum-nickel-manganese bronze alloy with high strength, good foundry characteristics, and ready weldability. More foundrymen are learning how to properly cast the tricky but wanted aluminum bronze alloys.

According to A. W. Bardeen, "The greatest advance in the past several years has been the upgrading of raw materials quality. No longer is the material a source of defective castings. Chemical specifications have been tightened; clean, smooth ingots are the rule and fractures are excellent."

New Applications

What are the new applications for brass and bronze castings? The consensus on this question was that the industry needs to concentrate on getting back the business it has lost to other metals and fabrication techniques. These applications are known, as are the customers and competitors.

Many foundrymen don't seem to be aware of their own product capabilities. No other cast alloy combines the superior corrosion and weathering resistance, thermal and electrical conductivity, high structural strength, ductility, architectural beauty, dimensional stability, and nonmagnetic, non-sparking properties inherent to the copper base family.

Today's advanced technology needs castings that can perform in corrosive environments at high temperatures and pressures—a natural for brass and bronze. The petroleum and chemical industries particularly have these needs.

"There appears to be more inter-

est in better wear-resistant material for the small power tool industry. Automation in all fields is seeking bronze and brass castings that are closer to size, lighter in weight, and trouble-free. Castings of high thermal conductivity and good high-temperature properties are being tested for portions of the guided missile and rocket program. Higher strength cast fittings that braze easily are being used in more corrosion applications, especially those involving sea water." These are the encouraging observations of John F. Klement.

Copper pipe and brass fittings for plumbing drainage fittings are providing a large and growing casting market. Weldable cupro-nickel is being used in nuclear submarines.

A. R. Barbour reports bronze bolts, above one-half inch diameter, can be cast to size (including the threads) more economically than by machining bar stock.

The Brass & Bronze Ingot Institute foresees an impressive number of new applications for bronze castings. Included are: bronze valves, fittings, hinges, and pulleys for household appliances; nonmagnetic structural parts for aircraft; electric motor parts; farm and garden tool components; cast sleeve bearings, diesel engine gears, pump parts, pole hardware, switching devices, and control mechanisms in railroad industry; valves, plumbing fixtures, doorknobs, hinges, window locks and pulls, mail chutes, and lighting fixtures for buildings; propellers and fittings for boats.

A substantial market for brass and bronze castings obviously exists. The challenge: "How do we get in on it?"

Improving Competitive Position

How can the brass and bronze industry best improve its competitive position today? Foundrymen have been doing a lot of positive thinking on this question. The key industry leaders contacted have come up with some encouraging programs for constructive action.

Probably tops on the list is the recognized need for a strong marketing effort on the part of brass and bronze foundries, both individually and collectively. Foundrymen are traditionally good craftsmen but notoriously poor at selling their own product.

"Have your technical people work closely with your sales people so that you will be able to reach beyond the purchasing agent to your customer's engineers. And make their problems, your problems."—Robert C. Stokes.

"Uses of special alloys for resistance welding, high conductivity, high strength, and corrosion resistance have increased in recent years. This involves the use of copper for high conductivity and aluminum bronze and manganese bronzes for high strength."—A. J. Moore.

"Brass and bronze foundrymen must be able to help with casting design and alloy selection to produce a product which meets the requirements of the buyer. They must know their costs to quote competitively with other materials and processes. We in the copperbase industry must continue to work with the engineers and designers of new products and supply them with the correct information to expand the use of copperbase castings."—Phillip E. Lankford.

"We must maintain our plants with up-to-date equipment and technology to supply casting users with quality castings at competitive prices. Institute an adequate cost system so you can analyze your competitive position. It is equally important to supply engineers and buyers with technical data and to assist in the design and purchase of engineered castings."—Jake Dee.

Marketing effort requires aggressive selling tactics combined with customer education. Advertising and direct-mail promotion describing the capabilities of your plant facilities and cast products will pave the way for your sales engineers. Get through to the design engineer and break down his "old-fashioned" prejudices against castings. Convince him that metalcasting is the shortest, fastest, most economical and reliable path from raw material to finished product.

"Foundrymen must aggressively hunt out and convert products over to copper-base castings—then stimulate the industry by publicizing the conversion."—F. L. Riddell.

To do this, you must convince design engineers that the properties and quality are available in copper-base alloy castings and that your foundry is capable of doing the job. Cost savings and quality must be engineered into a casting from its very inception on the designer's board to its ultimate delivery to the customer. Work closely with your customers so as to better understand their problems and thereby come up with the correct answers to suit the situations. Reach beyond the purchasing agent to your customer's engineers. And make their problems, your problems.

Organized marketing assistance has come to the industry from a number of sources. The Cast Bronze Bearing Institute has published an excellent manual on the use of bronze bearings and bushings. The Technical Manual of the Brass & Bronze Ingot Institute contains new factual technical and design information useful for merchandising your products. The same organization is currently conducting the First Annual Brass and Bronze Casting Progress Awards to encourage sound, progressive, and creative use of brass and bronze castings in industrial, architectural, and consumer products.

The American Foundrymen's Society, through its Brass and Bronze Division, is searching out new technical frontiers. The AFS Training & Research Institute is providing advanced education for upgrading in-plant personnel.

Better quality control in every foundry operation will reduce scrap and be ultimately reflected in lower costs, higher profits, and better castings.

Tighter specifications on properties, chemistry, appearance, and tolerances should be adopted to present a new engineering picture of copper-base castings and make them more competitive with other materials and fabrications. Stronger alloys are needed to meet new industry needs. Again, more research dollars are the only answer to this and other directions of growth.

W. M. Spear foresees "expanded use of high-strength corrosion resistant weldable bronzes for handling corrosive waters in converting salt water to fresh and treating waste water for reuse." And J. C. Fox predicts a profitable future for brass die castings once a suitable die material is found.

The 1960's will be a decade for weeding out foundries unfit for the highly competitive future.

R. A. Colton aptly paraphrases the situation:

"The brass and bronze industry is moving forward. Intelligent, capable leadership—recognition of the magnitude of the problems—creative, imaginative solutions—these are the ways we expect to recapture old markets, hold present ones, and develop the new."

What's Ahead for Copper-Base Foundries?

BY NORMAN A. BIRCH

THE BRASS and bronze casting industry needs a thorough understanding and awareness of the downward trends in its business volume and should come to grips with the situation here and now.

The industry trend is down, showing a gross 70 million pounds decrease in the period 1947-1959. This is a 13.8 per cent decrease, almost six million pounds and about 1.1 per cent per year. Sure, there are ups and downs. We hit a bottom of about 360 million in 1949 and haven't been that low since; and we hit 570 million in 1951 and haven't been that high again either. But the average, the trend, the balance of the highs and lows is downward at a rate of about six million pounds per year.

Now consider the trend in "rough" versus "machined" casting shipments. Rough casting shipments in the same period 1947-1959 decreased by 48 per cent, a rate almost four times the industry net loss. At

the same time the sale of machined castings increased about 76 per cent, or an increase averaging over six per cent per year.

This apparently favorable balance of a 76 per cent increase of machined and a 48 per cent loss of rough doesn't mean at all that there is any over-all growth; in fact the net decrease in volume was 27 per cent, or just twice that of the industry average. What it does show is that customers generally are shifting to "shelf items," parts wrapped and boxed ready for end use. Those foundries able to deliver a more sophisticated class of product—machined items—are picking up business at the expense of those who are simply rough castings suppliers. And with increasing labor costs, tighter alloy specifications, and tighter quality requirements, I predict this trend is with us to stay.

Copper Price Squeeze

To go on with our troubles, the number of brass and bronze foundries has dropped by about 300 during this same 1947-1959 period and is now down to less than 2200. So let's not kid ourselves with temporary spurts in the economy; the trend is downward, and we do have customer acceptance problems.

Add to this the upward trend in the world consumption of copper, now about 15 pounds per capita in the United States, plus the population explosion which will have an increasing effect each year. You can recognize that we are caught in a price squeeze, with increased demand for our base metal, copper, keeping the long-range price outlook spiraling upward. Our customers are increasingly pressed to substitute plastics, aluminum, die castings, anything, to get away from the inevitably increasing price of our product. Is it any wonder that we are not even holding our own but are actually sliding downhill?

Four Plus Factors

Now that we've examined the dark side of our situation let's look ahead to see if there is anything encouraging. I think we can count at least four definite "plus factors":

1. Continued improvements and aggressive growth in the areas of materials handling, molding machines, foundry equipment generally—making it better, faster, for less. In this we share, in fact, benefit from the activities of other metal divisions of the foundry industry.
2. Increased constructive technical assistance and consumer merchandising by the ingot makers. The Brass & Bronze Ingot Institute has, since 1940, published a Technical Manual, with the latest revision issued only recently. It contains new and factual technical and design information of the kind few industries could afford to pay for, much less be gracious enough to publish. This group of ingot smelters have spent $265,000 in the last three years in developing new factual data for you, and are reaching out beyond you to the consuming industries to help merchandise the merits of brass and bronze castings.

   Now B.B.I.I. is currently sponsoring a contest—the First Annual Progress Awards of $1000 in cash prizes for "new or improved uses and design of cast copper base alloys." The B.B.I.I. has also retained public relations counsel to keep the pot boiling. Their stake in the business is the same as ours, to have a healthy, preferably growing industry capable of generating profits.
3. We have new strength and growth in our professional societies—not only the American Foundrymen's Society, where we share the benefits to the whole castings industry, but also the Non-Ferrous Founders' Society, who are a clearing house for group action.
4. We have a new potential for bold action in the students specially trained for foundry careers by the Foundry Educational Foundation Schools and by the AFS Training and Research Institute.

Getting a New Look

The brass and bronze industry needs a "new look." Here's how to get it.

1. Develop a positive attitude about the future—there is going to be a real market for copper-base castings for a longe time to come; it's going to become more specialized; casting quality requirements will become stiffer; competition will continue to be tough; but there is a *real market*.
2. Get set to service your customers as never before. Pamper them, reach out to them, make their problems your problems.
3. Know your costs, sell at a fair price, and reach out intelligently for new products and new kinds of work; let's keep out of "price wars."
4. Train or hire your own technical expert. You're going to need him to set you up with specifications, alloys, basic shop controls. Let him help your salespeople reach beyond the purchasing agent to your customers' engineers.
5. Take an active part and give your financial support to your professional societies. At these meetings you develop the friendships and the cross-fertilizing of knowledge which is going to keep your foundry progressive and competent.
6. And lastly, learn how to merchandise and market your product. Be sure you know what you have to offer, both good points and weaknesses. Then go out and put your best foot forward with confidence.

Changes in Production Patterns
1956-58 average compared with 1946-48 average

United States Population	Up	21%
Wrought Magnesium	Up	280%
Magnesium Base Castings	Up	258%
Primary Aluminum	Up	215%
Molded & Extruded Plastics	Up	213%
Wrought Aluminum	Up	100%
Aluminum Base Castings	Up	58%
Steel Ingot	Up	30%
Gray Iron Castings	Up	2%
Steel Castings	Down	1%
Malleable Iron Castings	Down	4%
Copper Base Castings	**Down**	**19%**

Fig. 1

Magcobar Opens New Foundry Research Center

Modern facilities are being used to solve foundry problems involving green sand mixtures, molding, and reactions between molten metal and molds.

GREEN SAND PROBLEMS plaguing the foundry industry are under concentrated attack from the new Foundry Research & Development Center recently built by Magnet Cove Barium Corp., (Magcobar), Arlington Heights, Ill. Magcobar, a subsidiary of Dresser Industries, Dallas, Texas, is one of the nation's largest suppliers of bentonite to foundries. According to Gerald Morrical, foundry division manager, their research will be directed toward finding better ways to use bentonite and improve its quality.

With their new foundry laboratory, Magcobar brings the foundrymen's problems into their own shop for scientific evaluation and solution. For example, one project under way involves the development of a guide for steel foundrymen to permit them to adjust sand mixes for any bentonite liquid limit value. Thus far it is apparent that regardless of liquid limit value, sand mixes can be made to produce good or bad castings, depending on other factors.

When you step into the 2000-square foot foundry area (figure 1) you are immediately aware that equipment was selected to permit utmost flexibility. Practically any sand-metal problem can be tackled under conditions of extremely close control. Research Engineer George Vingas commented: *"Mold densities can be duplicated from one experiment to the next by compacting the sand in our special 150-ton hydraulic press. As high as 1200 psi can be applied to the sand in a 41 x 20-inch flask. Growing interest in ultra high-pressure molding has led us to exploration in this area. Already foundries are running into sand difficulties inherent to mold hardnesses up in the range above 90."*

Molds can also be produced more conventionally on the two jolt-squeeze machines. Centered in the molding area is a 250-pound capacity sand muller. The effects of mulling on machine molding is one of the priority projects under study at the laboratory.

Controlled sand experiments are meaningless unless the metal going into the mold is also pedigreed. To accomplish this end, two induction furnaces with a 50-kilowatt motor generator were installed. One

furnace can melt up to 230 pounds of steel and the other to 100 pounds. In the words of Arthur Zrimsek, research engineer, "*With this melting equipment we can control most melting variables, metal chemistry, slagging operations, atmosphere, and temperatures. The condition of the metal entering the gating system has a major influence on final casting quality. For example, ceroxide defects on casting surfaces, once blamed on sand, must be controlled from very start of melting through tapping and pouring.*"

In figure 2 researchers Vingas and Zrimsek examine two out of sixty steel test castings recently poured to evaluate scabbing tendencies of steel sand mixes. This is part of one of the long-range programs for improving the ability of green sand molds to withstand the drastic thermo reaction between molten steel and green sand.

Sand laboratory equipment, figure 3, includes universal compression testers, rammers, permeability meters, high-temperature dilatometer, and small mullers. These research tools are a must for piloting the procedures taking place out on the floor of the experimental foundry.

A line-up of three microscopes—low power stereo to 40x, high power metallurgical to 2000x, and petrographic—provide the means for delving into the realm of high magnification. Vingas, shown using the petrographic microscope, (figure 4) comments: "*The petrographic microscope is a rapid and sometimes the only means of identifying some of the complex metal-mineral oxides that form when molten metal and mineral molds meet with each other. A good example is the fayalite reaction between iron and silica. The resulting ceroxide is easily identified under the lens of the petrographic microscope.*"

Although their Research & Development Center has only been operating nine months, several important technical papers have been prepared:

a. A Systematic Approach to Foundry Sand Design & Control
b. Study of Surface Area Measurements and Theoretical and Experimental Relation to Angularity and Shape Factor of Foundry Sands
c. Bentonite Evaluation

Foundrymen will be interested to know that subjects under current examination and future appraisal include:

a. Pinholing of malleable iron
b. Dirt and scab-producing tendencies of steel sands
c. Basic principles underlying formation of scabs, buckles, and veins
d. Sand design for high pressure molding systems
e. Engineering properties of sands and influence of additives in the system.

Both Vingas and Zrimsek are active on technical committees of the American Foundrymen's Society. They have offered the use of the facilities for AFS committee meetings. Such meetings are unique in that the sessions include actual laboratory experimentation as a part of the agenda. Figure 5 shows members of the Mold Surface Committee (8-H), Sand Division, performing an experiment.

Fig. 2

Fig. 3

Fig. 4

Fig. 5

FROM SCOTLAND

Air-Setting Cores Speed Production

Mammoth cores weighing as much as 44,800 pounds harden quickly in place at Strathclyde Foundry.

by Arthur M. Shirley, Metallurgist
G. M. Hay & Co. Ltd.
Strathclyde Foundry
Glasgow, Scotland.

INSTALLATION of a sand slinger and sand conveyor system in our jobbing foundry led to a need for increased core shop production. The problem was solved by turning to the use of air-setting binder in the cores.

The history of the conversion from conventional type cores to air setting cores is quite remarkable. Great success was achieved in the initial use of this new type material. Advantages included fast production of intricate heavy cores with very little fatigue, good knockout properties, and fine casting finish. Several trials were then made to see the effect of heavy metal section on the air-setting cores. Results showed that if the usual precautions were taken, good results could be obtained.

A 560-pound capacity core-sand mixer is situated immediately adjacent to the core shop. Sand is delivered directly from a new type sand drier to an overhead storage hopper above the mixer. Oil and powder additions are then made to meet a predetermined time arrangement. Sand is conveyed directly from the mixer into the core boxes with minimum delay.

Core boxes travel on roller conveyor track from core shop to the filling position immediately in front of the mixer. When full, boxes are pushed along the track, allowing setting to take place (figure 1).

Whenever several cores are required off one box, core hardening is speeded by suitable addition of accelerator to the mix. The cores, when stripped, are blackened in the green state, using a spray gun. Then they are placed in the adjacent core oven for overnight drying. If quick delivery of cores is necessary, drying can be arranged to suit production.

The Strathclyde Foundry produces castings in high strength iron up to a limiting weight of 89,600 pounds. The bulk of the castings are in the 5000-33,000-pound class. Work is purely jobbing in character with very few quantity runs. Two main bays in the foundry are served by a stationary sandslinger unit situated in an opening between the bays. The slinger arm is 20 feet long and is of the power assisted raising type. It folds to enable the head to be switched from one bay to the other.

Immediately in front of the slinger position in the heavy foundry, a permanent pit 30 x 16 x 4 feet has been provided where all heavy flasks are rammed by slinger. Flask sizes vary considerably, from 20 feet long x 5 feet wide x 5 feet deep to 12 x 12 x 7 feet. Flasks rammed in the light foundry are of a smaller type and are filled at floor level. Mold drying is carried out in coal-fired, temperature-controlled ovens.

Here are several case-history examples of how the Strathclyde Foundry of G. M. Hay & Co. Ltd. used air-setting cores to make some really large gray iron castings.

Pump Body Castings

One of our earlier successes gained through the use of air-set oils was in the production of pump body parts. It was therefore gratifying to all concerned when the company received an order for the largest pump made to date in our area—namely, a 72-inch DXL pump. This casting was required in three parts—top, bottom, and cover.

The production of such large castings calls for high standards of skill from molders, coremakers, and metal production departments. As in the case of previous pump castings, no core boxes were provided. So the clay thickness method was used. In this method the mold is first prepared. Then a pre-

determined thickness of rock sand is placed on the mold, carefully following its contour. On top of this clay thickness, which is equal to the metal section required, the core is then rammed. When core is drawn the clay thickness stays behind to be removed as the last step in the molding cycle.

While the mold was being rammed the core grids necessary for the production of the large body cores were prepared. Grids were carefully positioned and air-setting sand shoveled in and tucked in between grid panels to ensure against pockets. Core interior was filled with broken, soft brick and dry ashes to cut down excessive use of sand.

The great size of the main body core led to making it in halves, thus making use of the fact that a wide web split the body of the casting. Each half core weighed approximately 14,000 pounds when complete! When the half body cores were sufficiently air hardened, a thickness of rock sand was laid on the top surface of the cores and the top core then made as described above.

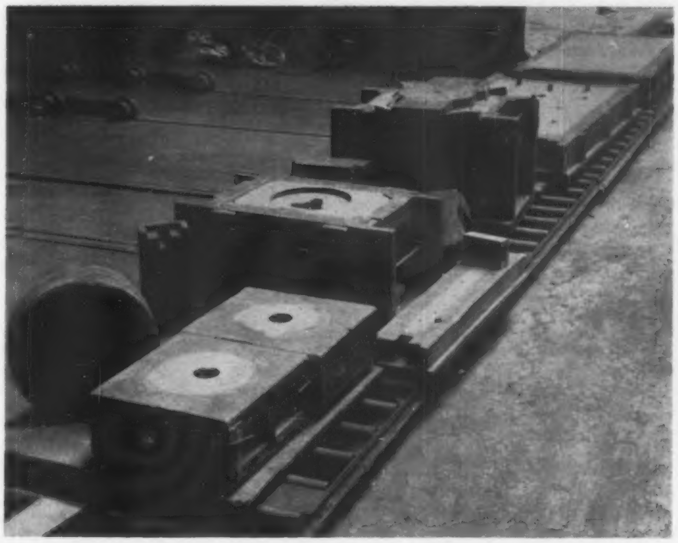
As soon as top core was sufficiently hard, the top part of the molding box was placed in position and rammed with sand. On being completed with runners and risers, this top part was then taken for finishing and final blackening before being oven dried.

The separate cores were then parted from the mold, finished, and dried overnight. During this time the mold was stripped of its clay thickness and finished prior to drying.

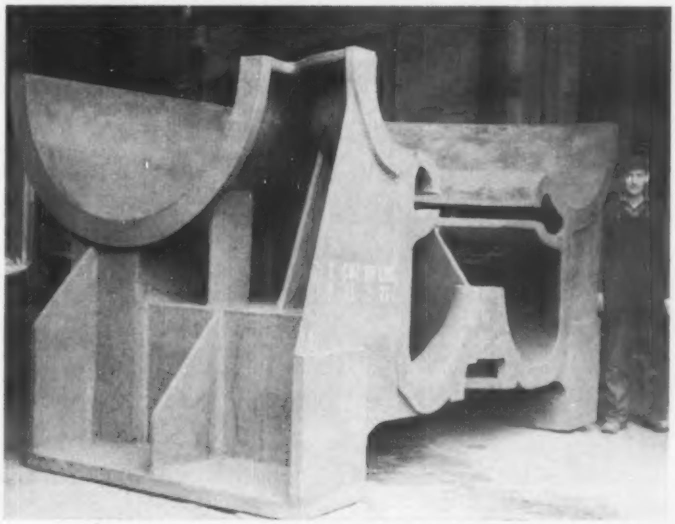
The properly dried mold was replaced in a specially prepared pit fitted with binding bars. Cores were then positioned with the utmost care and constant checking at all stages. Finally the mold was closed and secured down.

The metal required for pouring these castings was melted in our 8-ton per hour cupola and was cast using one ladle. Metal flow was exceedingly quiet with a soft evolution of gas from the vents. When sufficiently cool the casting was shaken out and easily cleaned. Cores had good knockout properties and surface finish proved excellent.

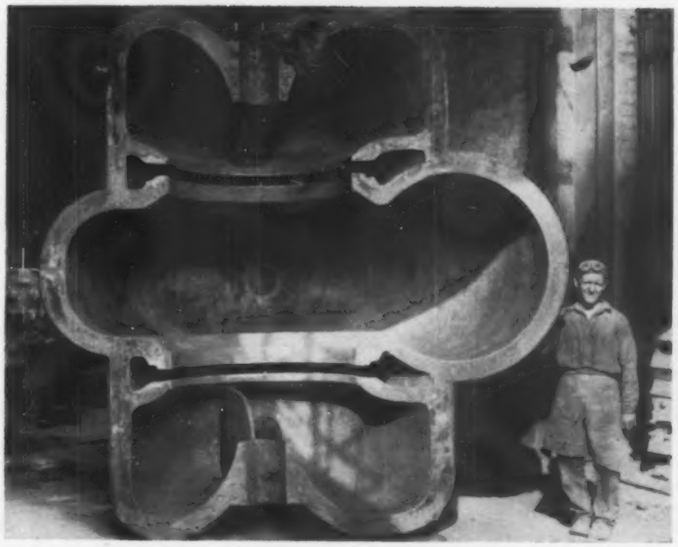
Figure 2 shows the 20,700-pound



1



2



3

4

5

6

(finished weight) bottom casing of the pump body. In figure 3 is the 12,900-pound pump cover casting.

A bedplate casting was produced in two parts because of its size. One piece weighed 60,000 pounds; the other 45,300 pounds (figure 4). The mold was rammed in a pit, figure 5, and dried by forced draft coke-fired heaters. All cores used were of the air-set type. In both cases producing the main cores called for a much larger amount of sand than previously handled. Figure 6 shows one of the main cores weighing 44,800 pounds. Four were necessary for the first part of the casting, and three weighing 33,600 pounds each were required for the second part of the casting. Figure 4 shows the sections and size of one of these castings. Note the sharp definition and high-grade finish obtained.

Unfortunately this type of casting suffers most from competition with weldments. If designers and their colleagues were kept more in touch with present-day foundry practice and the output of castings such as these kept to a high standard, we in the foundry industry would no doubt be in a much stronger position when similar types of castings were being sought in the future.

Conclusion

From the castings shown, it can be seen that with proper application the use of air-setting materials in the heavy jobbing foundry can be most successful. Skin finish meets high standards. The successful use and development of this new method of production should help in the future to retain for the foundry field some types of work at present in danger of being lost to weldments.

The author wishes to express his thanks to Mr. C. B. Scarcliffe, managing director of G. M. Hay & Co. Ltd., Strathclyde Foundry, Glasgow, for permission to publish this paper; and to the management and foundry staff for their help and encouragement during its preparation. He also wishes to thank the International Meehanite Metal Co., Ltd., for permission to enable the information in this paper to be made public.

MODERN CASTINGS wishes to thank the Institute of British Foundrymen for permission to condense this article from The British Foundryman through a special feature article exchange program arranged between the two magazines.

U. S. Point 4 Program Extends Foundry Techniques

As Trade and Industrial Education Advisor for the International Cooperation Administration in Iran, I am writing to tell American foundrymen how the United States is helping this overseas friendly nation to improve its metalcasting industry.

The objectives of U. S. technical cooperation, development assistance, and defense support are alike in that they seek to assist a newly developing country, such as Iran, take those steps that will better its living conditions, increase its economic strength, and improve its ability to defend its freedom.

Some 4000 United States technicians are today working in bilateral programs around the world. They are sent only on request of host governments to provide technical advice and guidance on specified projects. They work in partnership with officers of comparable rank and experience in the host country, effecting a direct exchange of know-how on a day-to-day basis.

Iran needs trained men in every phase of the foundry and metal melting industry. His Imperial Majesty, the Shahinshah; His Excellency Dr. Meheran, Minister of Education; and officials of the International Cooperation Administration foresaw a great need for vocational education teachers. So Teheran Institute of Technology was created to train such teachers. His Excellency, Engineer H. Nafici, Undersecretary of Vocational Training, has guided building of the school in the capitol city of Iran and planned the curriculum. He included a foundry course as one of the eight basic departments.

The new institute is composed of several modern buildings with all the equipment required for an up-to-date teacher's college. This institute was established through the cooperation of several organizations. The ICA's United States Operations Mission to Iran has contributed the necessary machinery and equipment at an overall cost of $1,250,000. ICA has also made available to the institute four Americans, trade and industrial education advisors, including myself, as a part of this team. Plan Organization of Iran has provided the buildings, and the Ministry of Education has made the land available for their construction.

My job is to advise, guide, and counsel the foundry program at the Institute. The foundry department teaches non-ferrous and ferrous foundry practice, core and dry sand molding, wood and metal patternmaking, sand testing, chemical analysis of metals, metallurgy, and metallography.

The course of studies at the Institute is four years in length and includes academic and professional subjects as well as practical training. The students, upon graduating, will teach in Iran's technical schools, trade schools, and technical high schools, as well as occupy technical positions of the Ministry of Education. The Iranian Ministry of Education has one of the best foundry schools for training teachers that I have seen in any country.

Also, beyond the planning stage, a joint project between the Iranian Ministry of Education and the International Cooperation Administration is the demonstration facilities for vocational education in Narmac, located near Teheran. Architectural plans for various buildings are completed or are nearing completion.

Construction of the facilities began early in 1960. Site layouts of buildings, walks, drives, water wells, and other facilities are also nearing completion, and in many cases completed. This school should be ready for operation about the same time as the first teachers graduate from the Teheran Institute of Technology, thus providing the needed well qualified vocational education teachers. Courses will run different lengths of time to provide various degrees of skill for the foundry industry.

This experience has afforded me much pleasure in being a part of the first technical college for graduating vocational and industrial education teachers.

I can see how these needed teachers are going to fulfill their education role and contribute to the welfare and to the needed development of the government of Iran. With teachers, we work not only with the present, but for the future.

Arthur S. Goss, Jr.
Trade & Industrial Education Advisor
United States of America Operations Mission to Iran

Leo Bourassa, instructor, Technical School, Trois-Rivieres, Quebec, is proud of the young boys he trains each summer in foundry techniques.

Canada Starts 'em Young

JUVENILE DELINQUENCY is non-existent in the town of Trois-Rivieres, Quebec. Why? Because the kids are kept busy learning trades in their leisure time. Tops in interest is a foundry course held each summer for young boys, ages 6 to 12 years, at the Trois-Rivieres Technical School. The course has been given every July for the last ten years.

Class is held in the morning from 9:00 to 11:45 A.M. when young boys have no place to go and the mothers are busy with housework. With an interesting morning ahead of them the boys wake up early and are very anxious to come to school. From 45 to 50 boys learn to make cast ashtrays, pans, lamps, mess-tins, book ends, etc.

Two teachers and a monitor demonstrate molding techniques. Then each boy makes his own mold. The teacher pours molten aluminum in the mold and cuts off the gates on a band saw. The boys grind metal flash and rough edges then polish castings on the buffer. Results are enthusiastically displayed by a graduating class in the lower picture.

All the schooling expenses are paid by the government of Quebec Province. We have noticed something very interesting about this course. When these boys grow up and reach 16 or 17 years of age, they come back to school to follow the technical course. At that time, it is easy to see they are well prepared to handle the assignments.

Boys can enroll in one of the four different programs—Technical Course, Trade Course, Apprentice & Special Course, or Night Course. The complexity of studies decreases in the same order. Currently there are 780 students enrolled in the three day programs and 750 taking night courses. School teaches Foundry, Patternmaking, Carpentry, Machine Shop, Electricity, Radio, Electronics, Automobile, Diesel, Refrigeration, Welding, Forging, Industrial Arts, Photography, Clock Work, and Masonry.

Students who cannot pay their tuition are able to obtain a scholarship from the Provincial Government. They are obligated to reimburse the government for half this amount as soon as they start working in industry.

Material Handling Efficiency Needs Well Planned System

A simplified, effective method. Practical experience is blended with technical data to:

a. justify equipment purchases

b. balance crew with changing work levels

c. justify department operations.

by Austin E. James
Haynes Stellite Co.,
Kokomo, Ind.

MANAGEMENT of the Haynes Stellite Company, Division of Union Carbide Corporation, contend that the supervision of material handling (a service department) is responsible for keeping its departmental operating cost in line with production requirements the same way as any other member of its production team.

The company has devised a material handling and control system which measures efficiency and at same time gives a sensitive control over materials on the move. This system is adaptable to any intermittent or variable type foundry handling operation. This system can help you to:

1. Establish operator and job efficiency levels.
2. Quickly determine inefficiencies caused by shifting work loads.
3. Adjust operating costs in proportion to manufacturing requirements.
4. Make corrective work assignments to maintain high operational efficiency.
5. Sell management on equipment needs.
6. Find material handling jobs which can be efficiently included in your services.
7. Assign responsibility and evaluate results.
8. Supply management with data so that performance can be accurately judged.

The plant produces many types of rough and finished metal castings and fabrications from wrought material. In addition to a number of standard products, the company produces a variety of highly specialized castings ranging from grams to hundreds of pounds on orders of any quantity. Melting facilities range from vacuum casting investment furnaces to 5-ton electric arc furnaces. The alloys produced are in the superalloy class providing both singular and combinations

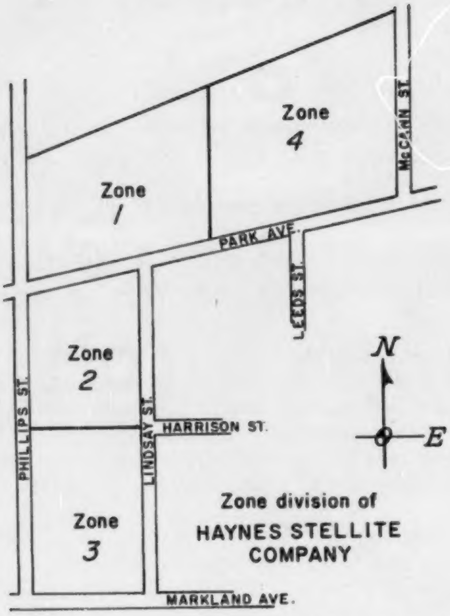


Fig. 1 . . . Plant is divided into four zones.

Zone normals in minutes

	Zone 1	Zone 2	Zone 3	Zone 4
Zone 1	4	5	9	6
Zone 2	5	4	6	9
Zone 3	9	6	4	12
Zone 4	6	9	12	4

Add 3 minutes for each loaded trip

Fig. 2 . . . Normal elapsed time for traveling from one zone to another is spelled out in this chart.

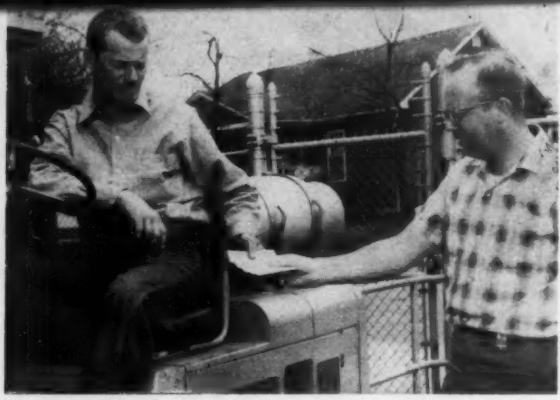


Fig. 3 . . . Assignments are handed to driver by dispatcher. Note the radio behind driver for instant communication.

Fig. 4 . . . Fork truck operator quickly finds assigned materials since exact location is specified on trip ticket.

of strength at high temperatures, resistance to strong chemicals, and resistance to wear and abrasion. The plant is L-shaped as shown in figure 1. Each leg of the L is approximately two city blocks long and one block deep.

Material Handling Services

The primary functions of our material handling department are the following services provided on a 24-hour per day basis.

1. Physically control process and scrap stores containing approximately three million pounds of metals made up of 125 distinct and separate alloys. This service also includes scrap removal from production areas.

2. Operate and control the central weigh room which includes the responsibility of weighing approximately 2500 heats each day. These heats (1 to 10,000 pounds) include in addition to revert scrap, iron, cobalt, nickel and tungsten alloys. Some heats contain more than twenty different raw materials.

3. Remove and dispose of debris from the plant.

4. Accumulate and store containers used in the plant consisting of pans, hoppers, barrels, special containers, pallets, etc.

5. Unload raw materials from rail cars and trucks.

6. Assist in inter-departmental and general material handling problems, including finish product handling

Fig. 5 . . . Rather than "dead head" back to Area I after making delivery, operator picks up scrap in Area 3.

Fig. 6 . . . Wagon train combines six trips into one in moving castings from sand foundry in Area 2 to shipping.

to stores and shipping. This service also includes a call service which is available to the various production departments for normal and emergency material handling.

First step in developing our system was a survey of all types of moves made in the plant by material handling equipment. From this survey, we divided the plant into twelve zones and developed a standard trip for each zone. A normal time for the standard trip in each zone was then constructed including time study and process delay factors. Data was accumulated and efficiencies were calculated.

For calculation purposes, a fork truck was considered performing work only when that truck was loaded. Driver received normal time and distance for each trip (loaded or empty) shown on his log. We calculated total operating time, distance traveled loaded and empty, normal hours loaded and empty, and their corresponding efficiencies. These particular calculations were eventually discontinued, but some rather astonishing facts about our handling became obvious. The following five points resulted from this study:

1. Forty-five per cent of total trips were inefficient because the trucks were empty.

2. Several operations required lengthy waiting of the fork trucks because they were used for load elevating where no other means was available. Two such operations on the second shift lowered the full shift efficiency by thirty per cent. Figures indicate this condition still exists.

3. Storage areas were not properly arranged for the most effective handling.

4. Load assignment and procurement time factors were excessive.

5. Material handling call service for other departments was not coordinated. So lower efficiencies resulted for the plant as a whole.

The New Plan

An improved eight-point program was developed after a careful examination and consideration of past experience:

1. Four zones were established as indicated in figure 1. A mathematical study of the factors involved indicated that a revision of the plant from twelve to four zones was logical. A distance factor up to one hundred feet proved relatively insignificant when compared to assignment and load procurement factors. Operating time differences between various size and brand fork trucks were also considered to be at sufficient variance to be significant.

2. Standard trips and normals were calculated (figure 2). Figure 2 contains the assigned zone normals in minutes. For example: If truck starts out in zone 1 and travels to zone 3, 9 minutes is considered a normal time lapse for the trip. If truck is loaded, add 3 min-

utes, making it 12 minutes. Note that with the four zone system, the table is simple enough to memorize.

3. A trip ticket was designed to be used for assignment purposes. The trip ticket eliminates instruction time and mistakes between the dispatcher and operators. Supervisors and clerks can make out trip tickets, but assignment to the drivers is done only by the dispatcher.

4. A dispatcher is assigned to coordinate material handling duties. He is specifically responsible for loading fork trucks in both directions. The trip ticket helps him perform this duty.

5. Lead time is requested for material handling call service. This lead time permits the dispatcher to plan these duties into the overall program.

6. Operators are usually assigned to the same work each day. As a result, efficiency levels for operators and their operations are established. By changing work assignments, cross checking of efficiency of both the worker and the job becomes very effective.

7. Areas showing empty travel time are investigated and often additional handling can be expected without additional cost.

8. With the installations of industrial radio, constant contact with the operator permits the dispatcher to further improve work assignment.

Keeping the Records

Management is naturally concerned with the cost of paper work. This present system has special interest because a minimum of paper work is required.

Figure 7 is a handling record complete with calculations. These sheets are attached to a clip board on the fork truck at the beginning of each shift. For simplicity of calculation, the sheet is assigned to the

HANDLING RECORD

490
467-394

DATE 3-5-59 1st Shift # 31 General Handling

FROM	TO	LOAD	OPERATOR	FULL	EMPTY	FACTOR	
1	3		Tobin		X	9	7:00 AM
3	3	6		X		24	
3	3	4			X	16	
3	1			X		9	
1	4				X	6	Total loaded 394
4	3			X		12	Empty 73
3	3			X		4	Total 467
3	1			X		9	
1	4				X	6	
4	3			X		12	
3	2				X	6	
2	3			X		6	
3	2			X		6	
2	3			X		6	
3	1			X		9	
1	4 •			X		6	
4	3			X		12	
3	3	6		X		24	
3	3	3			X	12	
3	1 •			X		9	
1	4				X	6	
4	3			X		12	
3	1			X		9	
1	4				X	6	
4	3			X		12	
3	3	4		X		16	
3	1			X		9	
1	4			X		6	
4	3			X		12	
3	3	2		X		8	
3	2				X	6	
2	3			X		6	
3	2			X		6	
2	3			X		6	
3	2			X		6	
2	3				X	6	
3	1		Tobin	X		9	
				41 Full trips x 3=123			

Fig. 7 . . . Handling record for each fork truck shows trips made and time involved for each shift.

FORK TRUCK CALCULATION

DATE March 1959 TRUCK 31 TYPE WORK General

DATE	DRIVER	TOTAL OPERATING TIME	TOTAL CREDITS	OPERATOR EFF.	LOADED CREDIT	HANDLING EFF.		DRIVER	TOTAL OPERATING TIME	TOTAL CREDITS	OPERATOR EFF.	LOADED CREDIT	HANDLING EFF.
Mar. 2	C.J.	480	365		300			J.E.	360	252		213	
" 3	C.J.	450	396		346			J.E.	360	240		234	
" 4	C.J.	480	386		330			J.E.	360	208		190	
" 5	C.J.	480	467		394			J.E.	360	203		185	
" 6	C.J.	480	418		374			J.E.	360	205		187	
Total		2370	2031	86%	1744	74%			1800	1108	62%	1009	56%
Mar. 9	C.J.	480	315		271			J.E.	200	194		185	
" 10	C.J.	330	282		237			J.E.	240	204		186	
" 11	C.J.	480	411		359			J.E.	240	201		183	
" 12	C.J.	480	451		397			J.E.	360	221		212	
" 13	C.J.	480	444		383			J.E.	360	219		210	
Total		2250	1903	85%	1647	73%			1400	1039	74%	976	70%

Fig. 8 . . . Fork truck calculation sheet employs figures from handling record for efficiency calculations.

fork truck, not the operator. The operator fills in the date, shift and fork truck number. He also logs his starting and quitting time in the right hand column.

For each trip he indicates "from" and "to" by zone number and indicates "full" or "empty" by checks. He signs his name in the "operator" column beside his first and last trip. The "loads" column is used to designate multiple identical trips. The "factor" column is used by the dispatcher for calculation purposes. The loaded credits are accumulated to the left side, the empty credits to the right side of the factor column. The credits appearing in the factor column are the zone normals (figure 2) in minutes multiplied by the number of loads.

The top figure in the upper right hand corner is total operating time (480). The left hand figure underneath is total credits loaded and empty (467). The right hand figure is total loaded credits (394). These are the figures which are transferred to the "Fork Truck Calculation" sheet which is shown in figure 8. Although "total operating", "total credited" and "loaded credited" times are recorded for each truck daily, actual efficiencies are only calculated weekly. We have found that a satisfactory estimate of daily efficiency can be obtained without actually making calculations.

Calculating Operator Efficiency

A "fleet calculation" (figure 9) is the total of the fork truck calculation sheets. This information is obtained from figure 8. In calculating operator efficiency, we consider the total time credited for both loaded and empty trips; however, the material handling efficiency is based only on loaded trips. The daily time totals are available by shifts for control purposes. Efficiencies are calculated on a weekly basis. Calculating time is approximately five minutes per truck per day.

Changes in efficiency levels may indicate a shifting work level or the shifting of work loads from one area to another. Either condition requires immediate reassignment of men and equipment. The responsibility of high efficiency operation must lie with the dispatcher as long as fork truck operators perform the work assigned to them.

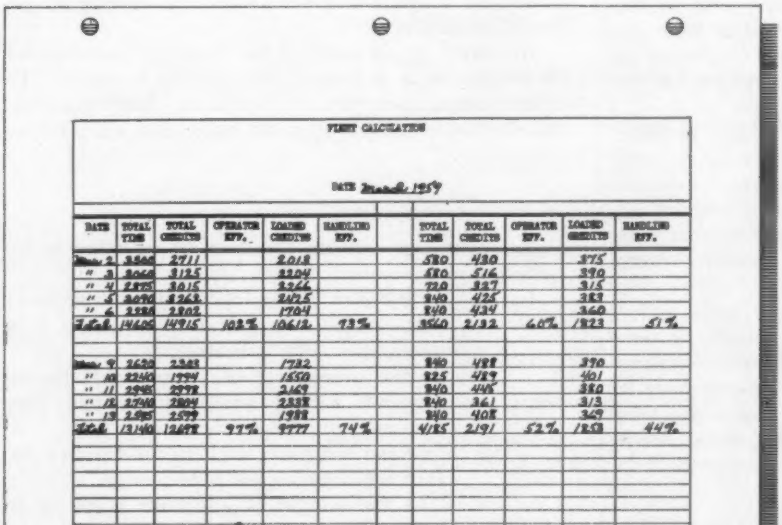
The System Pays Off

We like our control system because it has permitted us to establish operator and job efficiencies. It is flexible enough to indicate current inefficiencies and shifting work loads so that through corrective assignments, high operational efficiency is maintained. It has assisted us in selling management on our equipment needs. The system has controlled Haynes Stellite future by indicating areas of effective expansion and by supplying management with a yardstick to measure performance. Most important of all, the administrative costs are sufficiently low to be acceptable in the general cost picture.

If you desire the benefits of controlled operation, we suggest that you:

1. Make a survey of all the type moves made in your plant by material handling equipment.
2. Divide your plant into the fewest possible zones, based on work requirements you plan to control.
3. Develop a standard trip and normal for each zone, reducing all factors to their mathematical significance.
4. Develop the simplest method of calculation which will serve the needs of your plant.

Editor's note: This paper received one of the Clark Awards in a contest sponsored by the American Material Handling Society, Inc.



FLEET CALCULATION

DATE March 1959

DATE	TOTAL TIME	TOTAL CREDITS	OPERATOR EFF.	LOADED CREDITS	HANDLING EFF.		TOTAL TIME	TOTAL CREDITS	OPERATOR EFF.	LOADED CREDITS	HANDLING EFF.
Mar. 2	3500	2711		2018			580	430		375	
" 3	3060	3125		2204			580	516		390	
" 4	2875	3015		2266			720	327		315	
" 5	3090	3262		2425			840	425		383	
" 6	2980	2802		1704			840	434		360	
Total	14605	14915	102%	10612	73%		3560	2132	60%	1823	51%
Mar. 9	2620	2388		1732			840	488		390	
" 10	2240	1994		1550			825	489		401	
" 11	2945	2978		2169			840	445		380	
" 12	2740	2804		2338			840	361		313	
" 13	2595	2579		1988			840	408		349	
Total	13140	12698	97%	9777	74%		4185	2191	52%	1858	44%

Fig. 9 . . . Operator and material handling efficiency for the entire fleet calculated with this form.

How to Make Castings with Correct Composition

L. M. Elijah, George Sall Metals Co., Philadelphia, presents a set of important formulas for rapid calculation of furnace charges. Now you can easily achieve any desired alloy composition.

METALCASTING PLANTS can no longer be run solely by personnel who believe, "I've been in this business for twenty years and know all that is necessary." Experienced men are essential for successful operation. However, a balanced proportion of trained metallurgists and other engineers help to incorporate the adoption of advanced scientific controls so imperative for higher profits.

Lowering costs is a prime requisite and a major challenge to industry today, both because of ever growing competition from abroad and as a direct result of increasing wage demands, cost of materials, equipment, etc., in excess of gains in productivity.

The first basic requirement for metal producers is a fundamental comprehension of metal characteristics to develop optimum physical and mechanical properties with a minimum of rejects. This need is further accentuated as more castings are being used in the ever increasing field of aeronautics and missiles involving a greatly narrowing range of tolerances in chemical composition with increasing mechanical requirements.

An average foundryman when called upon to make simple, normal furnace adjustments can do so with a reasonable amount of accuracy. However, he shrinks visibly when faced with the prospect of making accurate furnace adjustments to achieve certain predesigned strength, electrical or corrosion-resistance specifications.

Normal composition limits are quite wide and a rough calculation usually suffices, especially if only one element has to be increased. When an element is to be decreased, or two or more elements have to be adjusted, or the specification tolerances are very narrow, the caster makes rough calculations, keeps his fingers crossed, and hopes for the best.

Current Methods

Let us examine the adjustment procedure sometimes employed for furnace melts. Assume we have an aluminum alloy (97.0% Al, 2.0% Si, 1.0% impurities) in the molten condition. We want to change it to an alloy containing 12.0 per cent silicon, with a tolerance of ±0.5 per cent (11.5 to 12.5 per cent is a fair range and should be easy to attain). Conversion of an alloy containing 2.0 per cent Si to 12.0 per cent Si involves an increase of 10 per cent. In adding 10 pounds of silicon to 100 pounds of melt, the total weight of melt will increase from 100 pounds to 100 + 10 = 110 pounds. The percentage of silicon in the final melt equals:

$$\frac{\text{Total amount of silicon}}{\text{Total weight of melt}} \times 100 = \frac{2 + 10}{110} \times 100 = 10.9\%$$

This is out of the specification range. To preclude this possibility, the metal men aim for the top of the range as a rule-of-thumb. It is evident that this is a hit-or-miss proposition and will not work with narrow ranges or when two or more elements have to be adjusted simultaneously.

By direct application of the formulae enumerated below, accurate and rapid changes can be made. (To attain the highest possible accuracy, further adjustments should include element losses and alloy recoveries.)

Basic Assumptions

Designate the various elements in an alloy to be adjusted as Element 1, 2, 3, . . . x

Let A% be the aim or final (desired or obtained) percentage of constituting elements in a given alloy *after* adjustments,

B% be the percentage of various constituting elements, actually present in the melt (*before* any additions are made),

c lb. be the weight of melt in the furnace before adjustments are made,

d lb. be the weight of additions made or to be made.

(Element numbers will be used as suffixes to designate specific elements when two or more elements are being considered, e.g. A_1, A_2, etc.)

CASE I *To increase the percentage of any one given Element x from B% to A% in c pounds of melt.*

A Amount of Element x to be added $= \frac{c\,(A\text{-}B)}{(100\text{-}A)}$ pounds.

Example To increase 5% aluminum to 10%, in an aluminum bronze melt of 3000 pounds, the amount of aluminum to be added is:

$$\frac{c\,(A-B)}{(100-A)} = \frac{3000\,(10\text{-}5)}{(100-10)} = 166.7 \text{ lb.}$$

NOMOGRAPH for $X = \frac{C(A\text{-}B)}{100\text{-}A}$

C = original weight of melt

B = original per cent of element x in the alloy

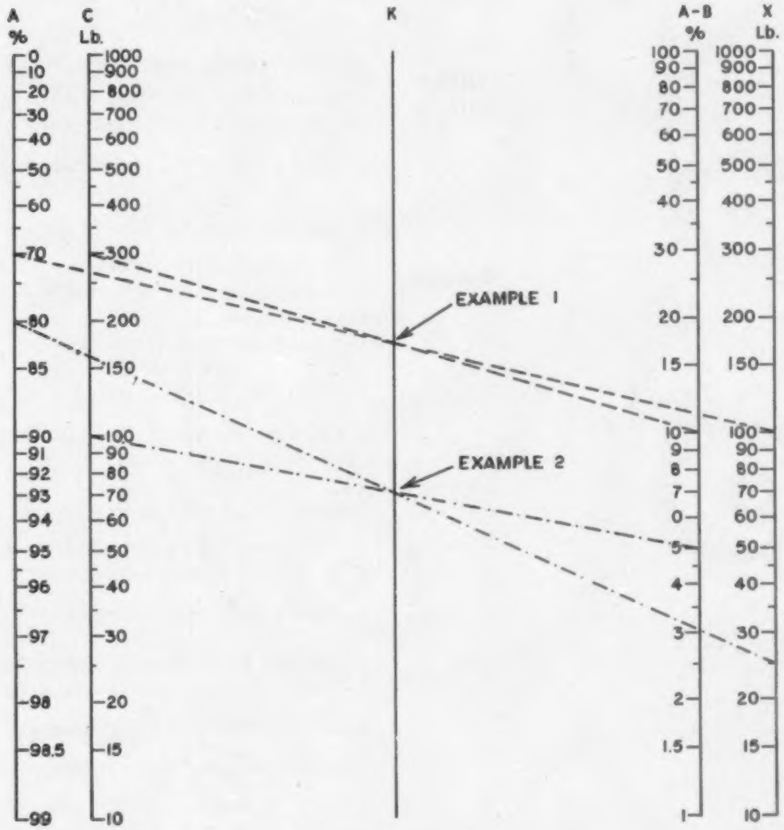
A = final per cent of element x desired in the alloy

X = weight of element x to be added

How to use Nomograph:

Example1—It is desired to change 300 pounds of 60-40 brass to 70-30 brass. Draw a line from 300 on C scale to 10 on A-B scale. Draw a line from 70 on A scale through point of intersection of first line on K line. Extend this line until it meets X scale. Read 100 pounds which is amount of copper that must be added.

Example 2—By same technique you find that 100 pounds of 75 Pb—25 Sn must have 25 pounds of lead added to make the alloy 80 Pb—20 Sn.



B To decrease the percentage of any one given Element x from B% to A% in c pounds of melt.
Amount of other elements (other than Element x) to be added $= \frac{c\,(B\text{-}A)}{A}$ pounds.

Example To decrease zinc from 10% to 5% in a nickel-aluminum-bronze, (Blowing would cause loss of other elements like aluminum, iron. This is costly.), dilution seems to be the most efficient method.
Weight of other diluting elements to be added is:

$$\frac{c\,(B-A)}{A} = \frac{3000\,(10\text{-}5)}{5} = 3000 \text{ pounds.}$$

This method is limited by the total holding capacity of the furnace.

CASE II *Effect of adding Element x to an alloy containing Element x.*
If we add d pounds of Element x to c pounds of a melt containing B% of Element x:

A Final (increased) percentage of Element x $= \frac{(B\,[c] + 100d)}{(c+d)}$ %

B Increase in Element x $= \frac{d\,(100-B)}{(c+d)}$ %

Continued on page 52

Example To evaluate the effect of adding excess of a certain element: If 400 pounds of copper were added to 10,000 pounds of a melt of 60 copper–40 zinc;

A Final percentage of copper will be:

$$\frac{(B\,[c] + 100d)}{(c + d)} = \frac{60 \times 10{,}000 + 100 \times 400}{10{,}000 + 400} = 61.54\%$$

B Change (increase) in percentage of copper is:

$$\frac{d\,(100\text{–}B)}{(c + d)} = \frac{400\,(100\text{–}60)}{(10{,}000 + 400)} = 1.54\%$$

(This value agrees with that obtained in IIA; 60.0 + 1.54 = 61.54%)

Effect of adding other Elements (2, 3, 4 etc.) on a given Element 1.

CASE III

A If we add d pounds of Element 2 or Elements 2, 3, 4 etc. to c pounds of a melt containing B% of Element 1:

a. Final (decreased) percentage of Element 1 $= \frac{B\,(c)}{(c + d)}\%$

b. Decrease in percentage of Element 1 $= \frac{B\,(d)}{(c + d)}\%$

Example In the above example, to ascertain the effect of the same addition on zinc (values obtained in II A and II B above can be used to check the figures obtained here).

a. Final percentage of zinc will be:

$$\frac{B\,(c)}{(c + d)} = \frac{(40 \times 10{,}000)}{(10{,}000 + 400)} = 38.46\%$$

b. Change (decrease) in the percentage of zinc is:

$$\frac{B\,(d)}{(c + d)} = \frac{(40 \times 400)}{(10{,}000 + 400)} = 1.54\%$$

Which verifies the results obtained in II B. Also 40.0 − 38.46 = 1.54%

B If we increase Elements 2, 3, 4, etc. (except 1) from $B_2\%$, $B_3\%$, $B_4\%$, to $A_2\%$, $A_3\%$, $A_4\%$ etc.: respectively in c pounds of melt, then

a. Final percentage of Element 1 $= \frac{B_1\,(100 - \Sigma A)}{(100 - \Sigma B)}\%$

[Where ΣA is the sum values $A_2 + A_3 + A_4$ . . etc. (except A_1)]
[and ΣB is the sum of values $B_2 + B_3 + B_4$ . . etc. (except B_1)]

b. Total weight of the additions will be $\frac{c\,(\Sigma A - \Sigma B)}{(100 - \Sigma A)}$ pounds.

The usefulness of these formulas will be illustrated later, in IV B.

Calculations for accurate overall furnace adjustments of two or more elements, for very narrow tolerance ranges of chemical analysis.

CASE IV

This is a general method that can be used very effectively on all alloy types. It will be followed by special applications where the calculations can be considerably shortened.

A To simplify this analysis, let us assume that the trace-impurities are within limits or that addition of further elements will bring these objectionables to within limits.

As before, let A_1, A_2, A_3 . . . . . Ax, be the final desired percentages of Elements 1, 2, 3 . . . . . x. (These values will be denoted generally as A_x, which would vary for each element.) Similarly, let B_1, B_2, B_3 . . . . . B_x be the percentages of Elements 1, 2, 3 . . . . . x, actually present in the molten alloy. (Denote these individual values generally by B_x). Then, if c pounds is the weight of the melt in the furnace to be adjusted, addition of each desired element to be made is: $\left[(A_x)\left(\frac{B}{A}\right)_{\text{max.}} - B_x\right]\frac{c}{100}$ pounds

Where $\left(\frac{B}{A}\right)$ max. is the maximum calculated value of all the various $\left(\frac{B_x}{A_x}\right)$ results.

Continued on page 54

Circle 162, Page 147

Example

This is the most involved analysis wherein a polynary alloy adjustment has to be made, holding the specification tolerances to within narrow margins. Assume we have a pentanary alloy (5 main elements), then the eight steps involved are detailed in Table I.

TABLE I—POLYNARY ALLOY ADJUSTMENT

ALLOY: Special Aluminum Bronze. FURNACE CAPACITY: 5500 pounds												
1.	Weight of metal charged in furnace = 4422 pounds (to allow for later additions) Theoretical recovery* = 4422 × 0.995 = 4400 pounds											
							Impurities					
		Cu	Al	Ni	Fe	Mn	Zn	Sn	Pb	Si	Others
2.	Permissible range %	78.0-79.0	9.25-9.50	4.25-4.75	4.25-4.75	2.50-3.00	0.10mx	0.05mx	0.02mx	0.05mx	0.15mx
3.	Aim (A_x) %	78.75	9.40	4.50	4.55	2.75	–	–	–	–	0.05mx
4.	Obtained (B_x) %	79.43	9.01	4.50	4.01	3.00	0.03	0.01	0.01	–	0.05
5.	(B_x) ÷ (A_x) %	1.009	0.959	1.00	0.88	1.091	–	–	–	–	–
6.	$\left\{\frac{B}{A}\right\}$ max. %	–	–	–	–	1.091	–	–	–	–	–
7.	Adjustments to be made	284.2 lb.	55.2 lb.	18.0 lb.	42.4 lb.	–	–	–	–	–	–
8.	Final adjustments to include element recoveries*	284.2 lb.	55.5 lb.	18.0 lb.	42.5 lb.	–	–	–	–	–	–

**Recovery will depend upon melting practice and type of furnace utilized*

1. Based on furnace capacity and previous experience, the weight of molten metal to be melted must be determined. This weight should be multiplied by the recovery factor (depending upon how long the metal stays in the furnace prior to adjustment)—to yield value c.

2. Tabulate the desired composition range.

3. Specify the exact composition aim (A_1, A_2 ..... A_x) of each element desired. Aim at the middle of a narrow range for stable elements and at the high limit for volatile or oxidizable constituents. The total of all elements must equal 100 per cent.

4. Also tabulate corresponding actual melt composition below those of Step 3 (B_1, B_2, B_3 ..... B_x).

5. Divide respective values of Step 4 by those in Step. 3.

6. Pick out the highest value obtained in Step. 5. This is $\left\{\frac{B}{A}\right\}$ max.

7. Insert respective values of each element in $\left[(A_x)\left\{\frac{B}{A}\right\}_{max.} - B_x\right]\frac{c}{100}$ This is the weight of each element to be added.

8. For maximum accuracy divide each weight by its recovery factor.

B

This is specialized application based upon the following conditions:

1. Only one element is in excess of specification;
2. Or if more than one element is in excess, then addition of the deficient elements should (a) bring all the excessive elements to within required tolerances and (b) permit those that are in tolerance to stay within their permissible ranges, e.g., if any element is at the lower limit of the tolerance range and would go out of specification on the addition of other deficient elements, then this element should also be considered as a deficient element and suitable additions made as follows:

Continued on page 56

APEX ALLCAST 70

An Aluminum Alloy that assures consistent high quality with economy

A general-purpose aluminum alloy, Allcast 70 offers superior mechanical properties as well as worthwhile savings through higher yields.

Pressure tightness, high fluidity with absence of shrinkage are assured by rigid technical control of all steps in its production.

Allcast 70 has delivered uniform performance in millions of pounds of sand and permanent mold castings produced over the past 15 years. Superior products such as Allcast 70 are a specialty of Apex . . . a name foundries know they can rely on every time.

Send for our brochure, "Apex Aluminum Alloy," which lists composition, mechanical properties and heat treatments of standard Apex products. No obligation.

Research leadership back of every ingot

Warehouse distributor of ALCAN foundry alloy ingot

APEX SMELTING COMPANY

CHICAGO 12 • CLEVELAND 5 • LONG BEACH 10, CAL.
SPRINGFIELD, OREGON (NATIONAL METALLURGICAL CORP.)

Circle 161, Page 147

Weight of each deficient element to be added is:

$$\left[\frac{A_x\ (100 - \Sigma B) - B_x}{(100 - \Sigma A)}\right]\frac{c}{100} \text{ pounds}$$

Where A_x and B_x are individual values and ΣA and ΣB are the sum of the respective values of the deficient elements that are being added.

Example Actually in the above example, only Cu exceeds its range. Ni and Mn are alright. Al and Fe are below their permissible ranges.
By adding Al and Fe, the Cu can be brought within tolerance, provided that the Ni and Mn are also not decreased below their minimum limit. Calculations will be as follows (in the example above).

ALLOY: (Same as Table I) FURNACE CAPACITY: (Same as Table I)

1. Weight of metal charged in furnace and theoretical recovery (Same as Table I)

		Cu	Al	Ni	Fe	Mn	Impurities Zn	Sn	Pb	Si	Others
2.	Permissible range	Same as previous example									
3.	Aim requiring least addtions (A_x) %	Below 79.0	9.375	No change	4.50	No change	–	–	–	–	–
4.	Obtained (B_x) %	Same as previous example									

Weight of each deficient element, Al and Fe, to be added is:

$$\left[\frac{A_x\ (100 - \Sigma B) - B_x}{(100 - \Sigma A)}\right]\frac{c}{100} \text{ pounds.}$$

Hence weight of necessary Al addition is:

$$\left[\frac{9.375\ (100 - [9.01 + 4.01]\ ) - 9.01}{100 - (9.375 + 4.50)}\right]\frac{4400}{100} = 20.15 \text{ pounds.}$$

And weight of necessary Fe addition is:

$$\left[\frac{4.50\ (100 - [9.01 + 4.01]\ ) - 4.01}{100 - (9.375 + 4.50)}\right]\frac{4400}{100} = 23.54 \text{ pounds.}$$

To evaluate the effect of these additions on other elements, employ Case III. B.a.

$$\text{Final percentage of unaltered element} = \frac{B_1\ (100 - \Sigma A)}{(100 - \Sigma B)}\ \%$$

$$\text{Thus final percentage of Cu} = \frac{79.43\ (100 - [9.375 + 4.50]\ )}{100 - (9.01 + 4.01)} = 78.65\%$$

$$\text{Final percentage of Ni} = \frac{4.50\ (100 - [9.375 + 4.50]\ )}{100 - (9.01 + 4.01)} = 4.456\%$$

$$\text{And final percentage of Mn} = \frac{3.00\ (100 - [9.375 + 4.50]\ )}{100 - (9.01 + 4.01)} = 2.97\%$$

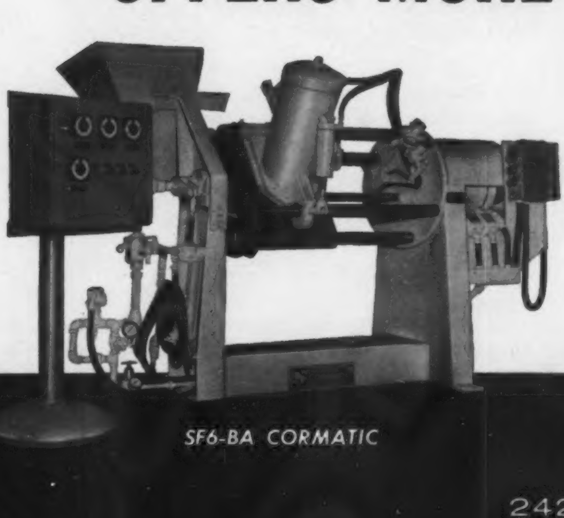
Thus Cu, Ni, Mn, are still within their respective ranges.
Total weight of addition of deficient elements is given by Case III. B.b:

$$\frac{c\ (\Sigma A - \Sigma B)}{(100 - \Sigma A)} = \frac{4400\ (\ [9.375 + 4.50] - [9.01 + 4.01]\ )}{100 - (9.375 + 4.50)} = 43.68 \text{ pounds.}$$

This value corresponds closely with 20.15 + 23.54 = 43.69 pounds obtained above. So neither Cu nor Ni additions are required. Also excessive Al and Fe additions have been minimized.

CONCLUSION With all the exactness of calculations, variations in chemical composition are still observed in a heat due to: (a) Preferential loss of a more volatile or oxidizable element. (b) Incomplete solution of a more refractory or less soluble element. (c) Precipitation of a more refractory or less soluble element. (d) Inadequate mixing. (e) Variations caused by large volume of metal. (f) Dendritic segregation accentuated by large sections. (g) Variation of laboratory analysis due to personal factors.

Faced with these variables of questionable control, it is always advisable to aim for the highest accuracy possible in all controllable areas.



SF6-BA CORMATIC

Castings Congress Papers

S. C. Massari

The most advanced metalcastings technology is revealed each month in this exclusive MODERN CASTINGS feature— Casting Congress Papers Preview. In this issue you will discover how to . . . conduct and interpret shatter tests for clay-bonded molding sands . . . cast a new high manganese nickel aluminum bronze . . . control costs in acid steel making . . . operate a lining-less water-cooled cupola . . . make and repair metal patterns by electroforming . . . meet the demands of missile industry with magnesium castings . . . minimize hot shortness in Alloy 20 stainless steel . . . gate and riser ductile iron castings . . . and control hot tearing of non-ferrous alloys.

TECHNICAL HIGHLIGHTS

Shatter Test for Clay-Bonded Sands .... *p 95*
This simple test requires little technical skill. Shatter test is a guide to molding sand toughness. Combined with green strength measurements, the shatter index can be used to indicate mold stripping properties.

High Manganese Nickel Aluminum Bronze ..... *p 67*
The casting characteristics of this promising naval propeller alloy have been given a thorough evaluation. Compared with nickel aluminum bronze, this high manganese variation has a higher yield point, a slightly superior ultimate tensile, and about equal ductility.

Economics of Acid Steel Practice .... *p 75*
Quality standards in steel castings hold and make business; sound operating costs make and control profits. The acid and basic steel melting processes are compared both technically and economically. Basic practice has higher refractory costs, more expensive forming materials.

Lining-Less Water-Cooled Cupola .... *p 83*
Cincinnati Milling Machine Co. is operating a lining-less water cooled hot blast cupola to produce one grade of closely controlled base metal. This metal is ladle treated to make castings ranging from a few ounces to 40,000 pounds in weight and from 1/4 to 6 inches section thickness.

Electroforming of Patterns .... *p 89*
This "cold casting" technique permits salvage of worn or undersized patterns, cladding of aluminum patterns, and electroforming patterns for precision casting and sand and shell molding.

Magnesium Castings for Missiles .... *p 91*
Careful foundry practices were used to produce prototype magnesium castings for missile applications. AZ 91 C alloy was produced with guaranteed minimum properties in intricate castings of at least 37,000 psi tensile, 18,000 psi yield, and 2 per cent elongation. These compare with average properties currently expected of only 25,500 psi, 14,500 psi, and 3/4 per cent for those three physicals.

Alloy 20 Stainless Steel Production .... *p 99*
Extreme chemical control is needed on this fully austenitic stainless steel because of its hot short sensitivity. Ti-Al-Va-Si-B additive has been developed to minimize this shortcoming. Carbon must be held in the narrow range of 0.05-0.07 per cent to meet minimum mechanical properties of 60,000 psi tensile, 27,000 psi yield, and 45 per cent elongation.

Gating and Risering Ductile Iron .... *p 103*
A panel of four experts tells how: 1) composition should be controlled to get maximum riser efficiency and improved fluid flow in gating system; 2) to design runner system and risers for best green sand practice; 3) to gate and riser ductile iron castings in dry sand molds; and 4) to use formulas for pouring time, effective sprue height, runner size, and riser dimensions.

Hot Tearing of Non-Ferrous Alloys .... *p 112*
Small amounts of alloying elements lower resistance of pure metals to hot tearing by forming films which remain liquid as much as several hundred degrees below freezing temperature of the pure metal.

The AFS Castings Congress papers are the most authoritative technical information available to the metalcasting industry. Over 100 papers were prepared by close to 250 authors and presented at the 1960 Congress in Philadelphia, May 9-13. Papers receive preview publication in MODERN CASTINGS and then are bound into the annual volume of AFS TRANSACTIONS for permanent reference. All papers have been approved by the appropriate Program and Papers Committee of the sponsoring AFS Technical Division. They are then edited by AFS staff members C. R. McNeill and M. C. Hansen. Written discussion of these papers will be welcome.

SHATTER TEST USE FOR CONTROLLING CLAY-BONDED SAND

by W. B. Parkes and R. G. Godding

ABSTRACT

The procedure of the shatter test for clay-bonded sand is described. A standard AFS test piece is stripped by means of a stripping post so mounted that immediately after leaving the container the test piece falls vertically through a height of 6 ft onto a solid anvil set in the center of a ½-in. standard sieve. The shatter index is the percentage by weight of the test piece which remains on the ½-in. mesh sieve. The shatter test should be used with the green strength test. An appendix gives the apparatus necessary for the shatter test, the method of testing and the precautions necessary when using the test.

THE SHATTER TEST

This test was first described by Graham,[1] and a standard procedure for carrying it out was later prepared by the Joint Committee on Sand Testing.[2] It is widely used in British foundries. The test is carried out by stripping the standard AFS test piece by means of a stripping post so mounted that immediately after leaving the container the test piece falls vertically through a height of 6 ft. onto a solid anvil set in the center of a ½-in. standard sieve.

On striking the anvil the test piece breaks up and the coarser fragments are caught on the sieve. The result is reported as the "shatter index," which is defined as the percentage by weight of the test piece which remains on a ½-in. mesh sieve. The apparatus required, and the method of carrying out the test are described in the Appendix.

In order to control the "moldability" of a sand the shatter test is used in conjunction with the green strength test. Neither test alone is sufficient.

The test satisfies the requirements of a routine test for foundry sand in that it can be carried out quickly, requires no great skill and can be interpreted by the small foundry without a technical staff.

TESTS FOR "MOLDABILITY"

Routine tests for the control of foundry sand are almost universally derived from those originally prepared by the AFA, and remarkably little modification of the original recommendations has been desirable. Of these routine tests, that for green strength has been in general use to determine whether a sand is suitable for making the mold, separating it from the pattern and assembling and under some conditions this procedure is satisfactory.

W. B. PARKES and R. G. GODDING are with British Cast Iron Rsch. Assn., Birmingham, England.

For example, if the moisture content, type of clay and grading of the fraction other than clay are unchanged, then the molding properties are likely to remain constant so long as the green strength remains the same. However, when any of the other factors mentioned changes, a constant green strength does not guarantee constant molding properties. It is possible to obtain either good or bad molding properties as required with green strength anywhere in the range 0-20 psi by a suitable selection of grain and binder.

GREEN STRENGTH TEST LIMITATIONS

There are many indications from the foundry that the molding properties of a sand are not defined by the green strength.

On a line of molding machines, when stripping is satisfactory except for an occasional difficult pattern, a fairly widespread practice is to take a little sand bonded with organic binders from the core shop and use it as a facing sand on that part of the pattern where the sand is breaking away. This is usually successful. The molders attribute this to the clay-bonded sand being too weak, whereas the core shop sand has sufficient strength, for instance, in one such case the "too weak" molding sand had a strength of 8 lb/sq in. and the "strong enough" core sand one of 8 oz/sq in.

If the green strength of a clay-bonded sand at different moisture contents is measured a curve like that shown in Fig. 1 is obtained.

In the region where the line is broken green strength is high, but it would be difficult to obtain a satisfactory draw even with a simple pattern. Indeed, towards the low moisture end it is difficult to obtain concordant results in the strength test. Where the solid line commences, it is possible to strip from fairly simple patterns only; but as the moisture content increases, more and more complicated patterns can be used until the point is reached when the sand fails through stickiness.

In this case molding properties improve as strength decreases.

If, using the same kind of sand and clay as in the sand shown in Fig. 1, which had good molding prop-

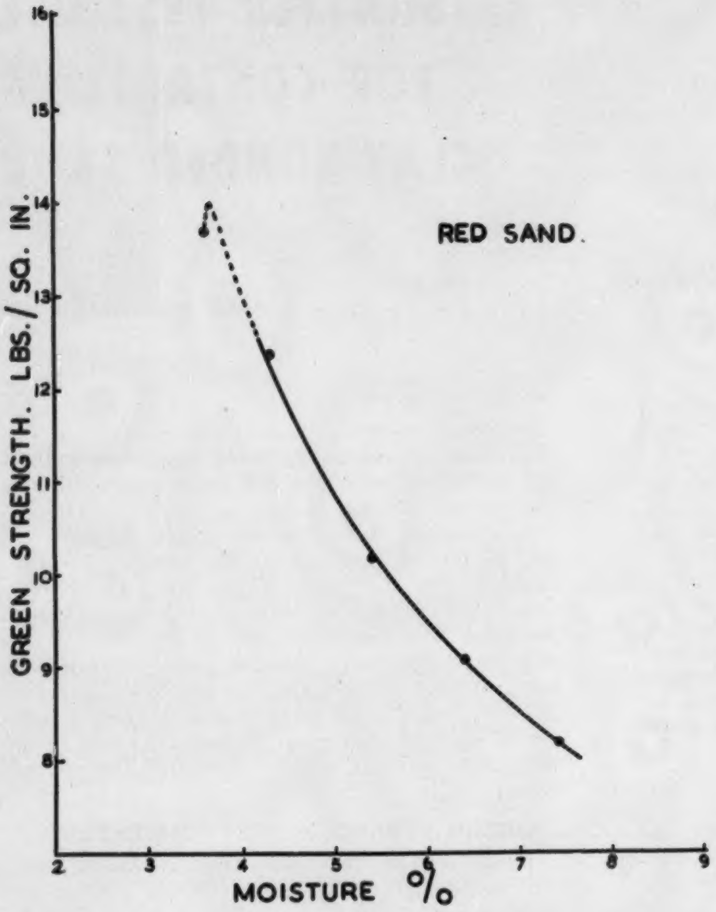


Fig. 1 — Green strength moisture curve of clay-bonded sand.

erties with 10 per cent clay and 2½ per cent water, increasing quantities of clay and water in the ratio 4 clay to 1 water are added, then green strength will increase and molding properties improve until the point is reached when the sand is so strong that it cannot be rammed properly. In this case molding properties improve as strength increases. Clearly, some factor other than green strength is involved.

CRACKING OF RAMMED SAND

In an attempt to illustrate the difference between sands with good and with poor molding properties, one sand of each kind was prepared, both having a green strength of 8 psi. There are several ways of doing this. Standard test pieces from each were prepared and broken on a spring balance machine, a film of the test piece being taken during the operation. Stills from the film are shown in Figs. 2 (poor molding properties) and 3 (good molding properties).

In each case photograph (a) shows the test pieces when the load was first applied, (b) when the first crack appeared and (c) $\frac{1}{50}$ sec after (b). At this point the sand with the poor molding properties collapsed, but the sand with the good molding properties had not. To get to the condition shown in 3(d), which corresponds to that shown in 2(c), the load had to be applied for a further $\frac{1}{50}$ sec. The final photographs show the broken test pieces.

Comparison between photographs 2(b) and 3(b) shows the difference between the physical properties of the two sands. When the first crack appears in 2(b) there has been little change in the dimensions of the test piece, but in 3(b) the test piece has bulged and become shorter. The extent of this shortening and deformation can be used as an index of the molding properties of the sand.

REASONS FOR OBTAINING A POOR STRIP

When a pattern is being removed from a rammed mold, the friction between pattern and vertical parts of the mold wall is high and usually exceeds the transverse strength of a thin layer of sand near the mold surface. The pattern drops out a layer of sand as shown in (A) of Fig. 4.

In order to avoid damage to the mold in this way, the size of the mold cavity has to be increased in order to provide a clearance and eliminate friction as far as possible. In machine molding this is done by means of a vibrator, whereas hand molders frequently insert a rapping spike into the pattern (as shown in (B) of Fig. 4), and strike this in such a way as to obtain lateral movement of the pattern.

A bad strip is obtained if the mold cavity is not sufficiently enlarged or if the mold cracks during rapping or vibrating. The latter occurs if the deformation imposed on any section of the mold is greater than it

can stand without cracking. Again, the important property is deformation.

DIRECT MEASUREMENT OF DEFORMATION

The importance of deformation has long been recognized. There are numerous references to it in the literature during the last 20 or more years, and some of the green strength machines used for testing foundry sands have attachments for measuring this property. The behavior of a plastic material when being deformed, however, is somewhat complicated, and many attempts to relate the behavior of a sand mold during stripping to the deformation so measured have been unsuccessful.

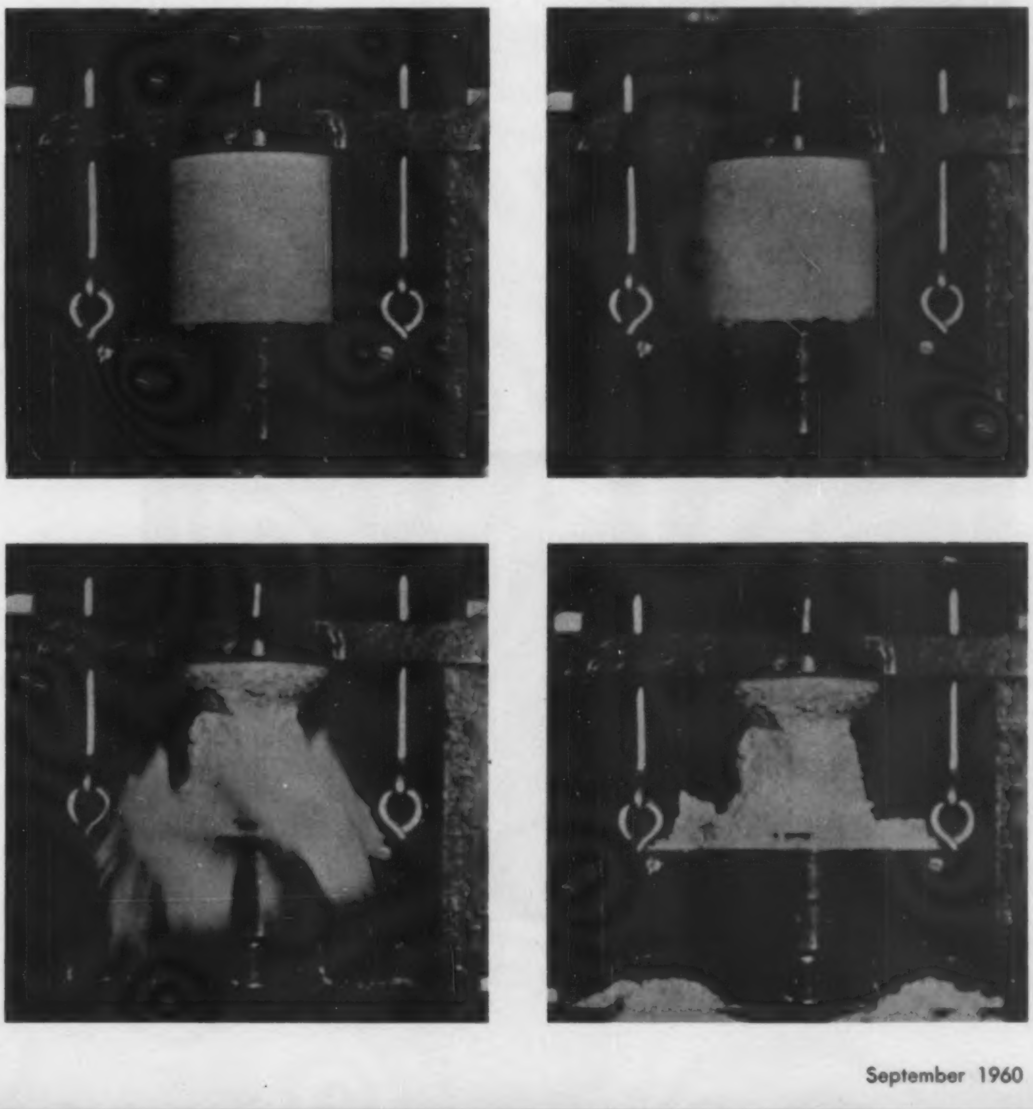
The probable reason for this lack of agreement is that it is difficult to measure the deformation of a plastic material, the difficulty being in part due to the actual difficulty in measuring; and in part to the need for specifying several factors, each of which influences the result obtained.

Figure 5 shows the stress/strain curves of two sands. Curve (a) is that of a clay-bonded sand with a low moisture content, a sand which could only be used for making single molds. The strength of this sand is 10 psi, and the deformation 10^{-3} in. on 2 in. An attachment to a dead load machine can measure this deformation fairly accurately.

Curve (b) is that of plastic sand with higher moisture content and a cereal addition. This sand has excellent stripping properties but is too tough to ram easily. It is difficult to decide the exact deformation at maximum stress because of the flat top of the curve and it could be anything between 40×10^{-3} and 65×10^{-3} on 2 in. This kind of curve can only be obtained by means of an apparatus in which load is reduced as soon as the test piece begins to deform rapidly. With a dead load machine the deformation obtained usually lies between deformation at maximum stress and deformation to rupture, and the result depends on the rate at which the load is applied and on the characteristics of the machine.

When a mold is vibrated or rapped the rate of application of the load is extremely rapid, and conditions are those of impact rather than those of steady

Fig. 2 — Poor molding properties. ***a*** **— upper left;** ***b*** **— upper right;** ***c*** **— lower left;** ***d*** **— lower right.**



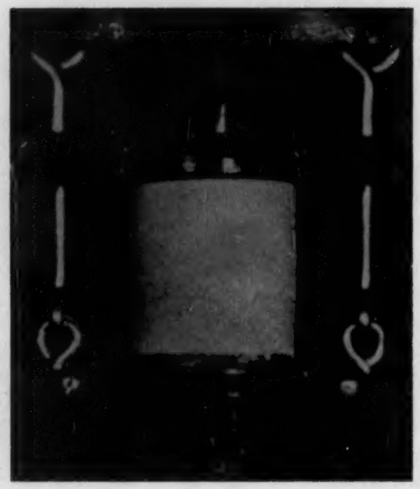
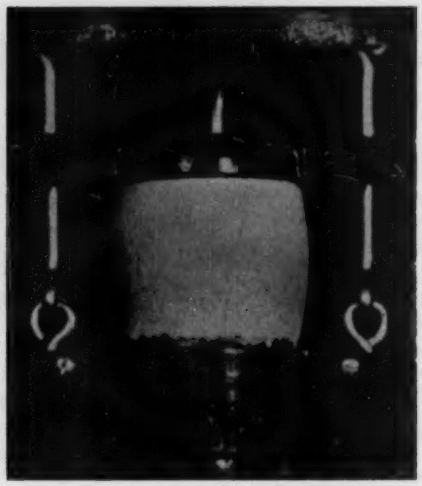
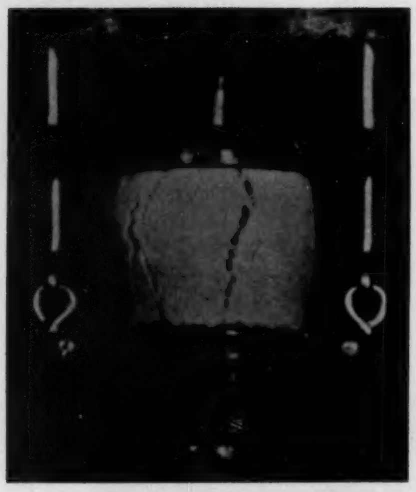
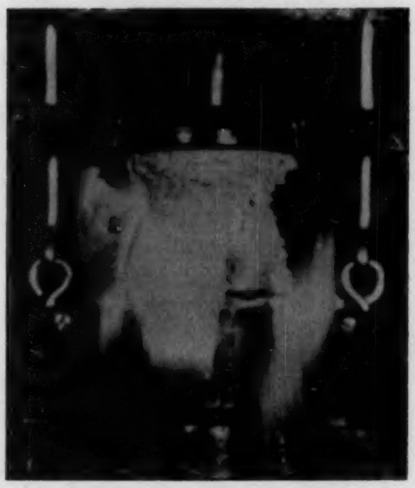
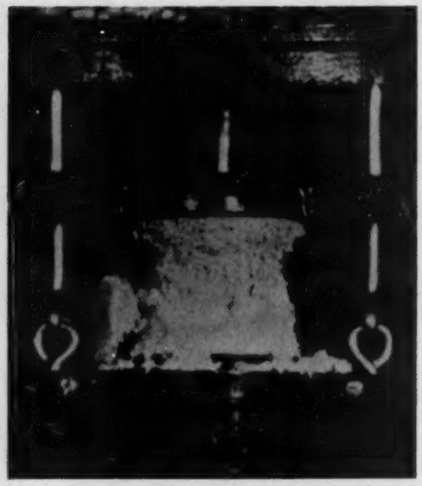




Fig. 3. — Good molding properties. *a* — upper left; *b* — upper right; *c* — left; *d* — lower left; *e* — lower right.

loading. All attempts to measure directly deformation under impact have so far failed.

INDIRECT MEASUREMENT OF DEFORMATION

Since direct measurement of deformation was not practicable at the time, indirect methods were considered, and the most promising appeared to be by means of an impact test similar to the Izod. Two obstacles were found. In the first place, green sand is such a weak material that it is difficult to build a machine suitable for routine testing on which friction losses are low enough to be ignored. In the second place, the energy absorbed in moving the broken half of the test piece was greater than that required for breaking, i.e., if the test were carried out on a test piece already cut into two pieces, the result differed little from that obtained when a complete test piece was used.

SHATTER TEST USE

When Graham published his description of the shatter test it offered a possible solution to the problem of the impact test in that the test piece was broken by impact and friction losses did not interfere, the breaking force being supplied by the inertia of the falling test piece. The apparatus was well suited for routine testing.

The test was first described as one for measuring "flowability," and was soon adopted by a number of foundries. It was found to be more satisfactory as a measure of the stripping properties, but after longer experience this was shown to be true only if the green strength remained constant. If shatter index remains constant and green strength rises, the mold is liable to crack during vibrating or rapping.

It is not possible to derive deformation from the results of the shatter test, and, moreover, the test has a serious limitation in that it is quantitative to only a limited extent. If two sands have the same shatter index they have the same toughness under impact conditions, but if their indices differ it is only possible to say that one is tougher or less tough than the other. The curve relating toughness to shatter index approximates to a hyperbola with the asymptote at 100 per cent.

Although the shatter test is thus limited, it can still be used in conjunction with the green strength test for routine control of prepared foundry sands in the following way.

The shatter index measures toughness which can be defined by the area under the stress/strain curve, and is therefore approximately proportional to the product of strength and deformation. If we have two sands *A* and *B*, each with a shatter index of 70, but *A* has a strength of 10 psi and *B* a strength of 20 psi, then they have the same toughness but the deformation of *B* is only half that of *A*.

	Sand A	Sand B
Shatter Index	70	70
Toughness	X	X
Green Strength	10 lb/sq in.	20 lb/sq in.
Deformation	$\frac{Kx}{10}$	$\frac{Kx}{20}$

It is not necessary to know the value of *X* or the units in which it is measured, or the value of *K*. Sand

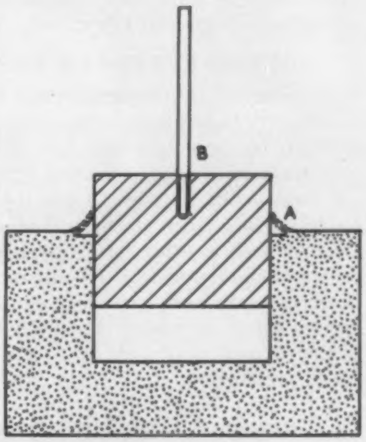


Fig. 4 — Breakage of mold during pattern strip.

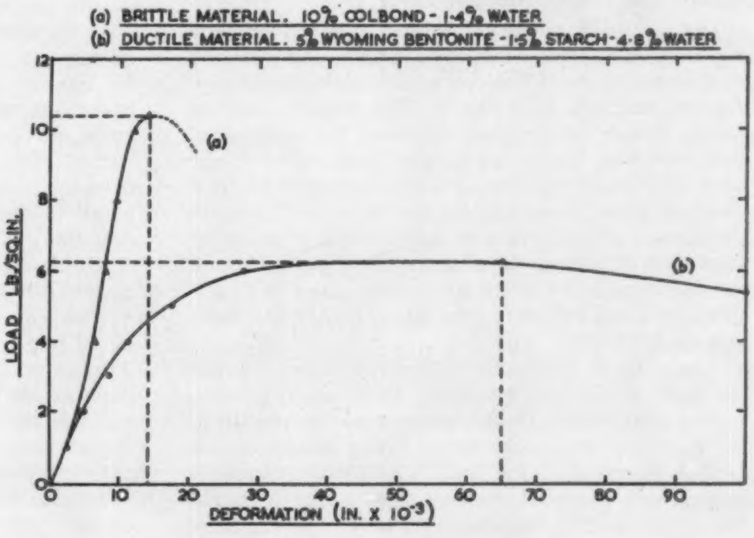


Fig. 5 — Stress-strain curves of two sands.

A is typical of the sands used for machine molded castings with a not too difficult draw. Sand *B* would be unsatisfactory for most work as the mold would tend to crack when vibrated.

If the strength fell to 5 psi, and the shatter index remained at 70, deformation would be doubled. The mold would strip nicely, but with double the deformation resulting from half the load there would be a greatly increased risk that the pressure of the metal during and at the end of pouring might cause the mold to deform sufficiently to give an oversize casting. If the green strength is as low as 5 psi, as may occur if the sands are mixed by hand, royer or sand cutter, the shatter index should be reduced to 50-60 to avoid swelling.

In the foregoing, toughness was measured under impact conditions, whereas the green strength was measured in the normal way. With the high rates of shear which occur in the shatter test, green strength will certainly be much higher, and on this account it was at first feared that the relationship between shatter index and green strength might not always give satisfactory control. Although the test has been used by a large number of foundries for almost ten years, no such cases have come to hand. It appears, for the range of clay-bonded sands used in the iron foundry, that there is a sufficiently constant ratio between the strengths at high and low rates of shear.

GREEN STRENGTH IMPORTANCE

In order to use the shatter test for sand control, it is necessary to know also the green strength, but green strength is also important, per se. It is quite easy to produce a sand with sufficient deformation to enable the mold to be separated from the pattern while still having a low green strength, Indeed, it is possible to do this with a silica sand and water alone, but the green strength is so low that the mold would, in many cases, collapse under its own weight. With somewhat higher green strengths the mold may sag or distort under its own weight or, at a later stage as a result of metal pressure.

An Example of Control By Means of the Shatter and Green Strength Tests

The failure of either the shatter or green strength test alone to control a foundry sand mixture was seen in the case of two foundries where castings and production methods were similar. The castings were of simple design and required no cores, the metal/sand ratio was high and a completely synthetic sand was used. One foundry added sufficient clay to maintain a constant green strength, and the other sufficient to maintain a constant shatter index. After a period of time both foundries were in serious trouble because the molds cracked while being vibrated, and small sections remained behind on the pattern when the mold was removed.

The cause of the change in molding properties was the same in the two foundries. Each produced castings of considerable thickness which had to remain in the mold for some time before being shaken out. A large proportion of the sand was therefore strongly heated, and much of the clay present lost its bonding power entirely. Since no cores were required, there were no additions of clay-free sand from this source, and the only sand entering the system was the small amount of makeup sand required to keep the system full. In consequence, there was a continued increase in the amount of clay which had no bonding power, and such "dead" clay has an important effect on the properties of the new clay added to maintain the sand in suitable condition for molding.

This effect was demonstrated in the following way. A synthetic sand was prepared by milling a silica sand with 5 per cent bentonite, and the green strength and shatter index were measured over a wide range of moisture content. The sand was heated to 800 C (1472 F) for some time, and on milling with water it could be seen that the bonding power of the clay had completely disappeared. Five per cent of new bentonite was added and the sand re-milled and tested as before. Green strength/moisture and shatter index/moisture curves showed that three changes had occurred:

1) All curves had moved in the direction of high moisture content.
2) Green strength had increased.
3) Shatter index had decreased.

The sand was heated again and remilled with water and again strength and shatter index were negligible. A further 5 per cent bentonite was added and tested as before. The process was again repeated so that the final sand contained 15 per cent "dead" clay and 5 per cent active clay. The green strengths and shatter indices of the four sands are shown in Figs. 6 and 7.

Both the foundries mentioned earlier maintained a close control over their sand. Moisture content, permeability and coal dust, were kept constant, as were shatter index in the one case and green strength in the other, but both foundries ran into difficulty, and a glance at Figs. 6 and 7 shows why.

Since "dead" clay raises green strength, the foundry maintaining the constant green strength was actually reducing the amount of active clay present. The shatter index was therefore falling more rapidly than is shown in Fig. 7. With a constant green strength, a fall in shatter index is due to a fall in deformation, and on this account the molds cracked when vibrated.

In the second foundry the shatter index was kept constant, but since "dead" clay (which reduces shatter index) was increasing, the amount of new clay had to be raised. This in turn further increases the green strength, which had already been raised by the "dead" clay. An increase in green strength with a constant shatter index has been shown to be due to a fall in deformation, and the second foundry was eventually in precisely the same difficutly as the first. The only difference was that a somewhat longer time elapsed before the end was reached.

With either test used alone, control is inadequate, but if both tests are used control can be maintained. Two completely independent parameters, strength and deformation, are involved and no single figure is adequate to define both. It is not necessary for a routine test to measure both, but it must be able to show, once the properties desired have been decided upon, whether either has changed. This is done most easily by the combination of green strength and shatter test.

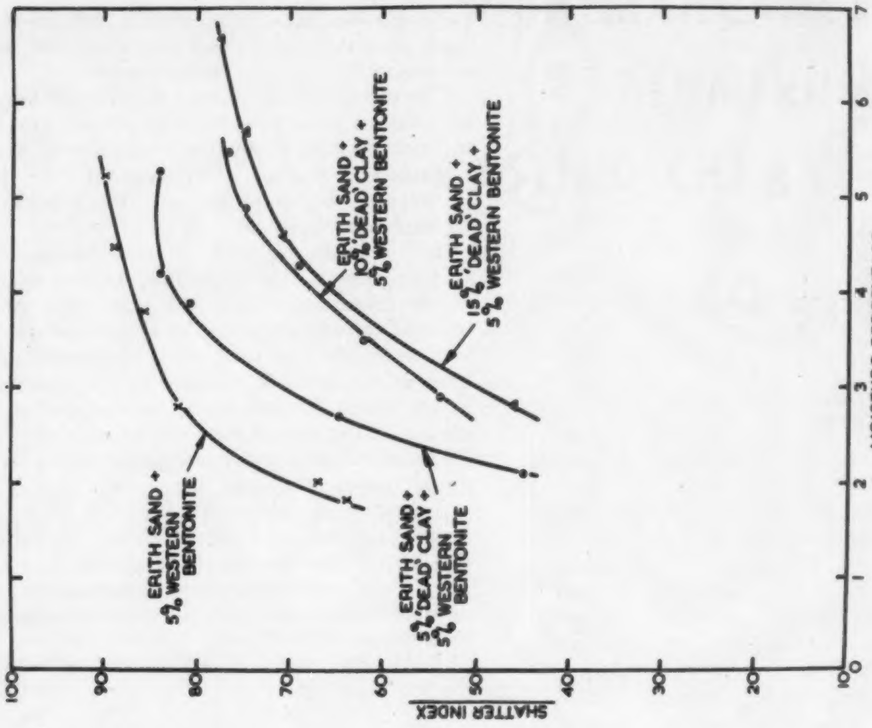


Fig. 7 — "Dead" clay effect on shatter index.

REFERENCES

1. Graham, E. L., *Foundry Trade Journal, vol. 84,* pp. 365-367 (April 15, 1948).
2. Sand Committee on Sand Testing, "Methods of Testing Prepared Foundry Sands," Second Report, Manchester, Institute of British Foundryman, 8 pp (1954).

APPENDIX

Apparatus Required and Method of Operation for Shatter Test

Apparatus. Apparatus for carrying out the test is shown in Fig. 8 and consists of:

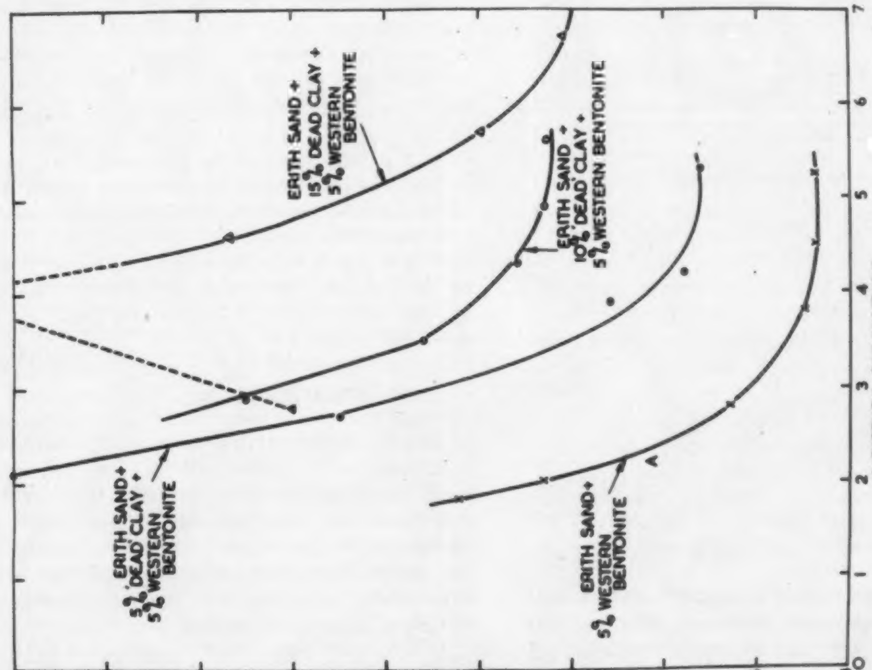


Fig. 6 — Dead clay effect on green strength.

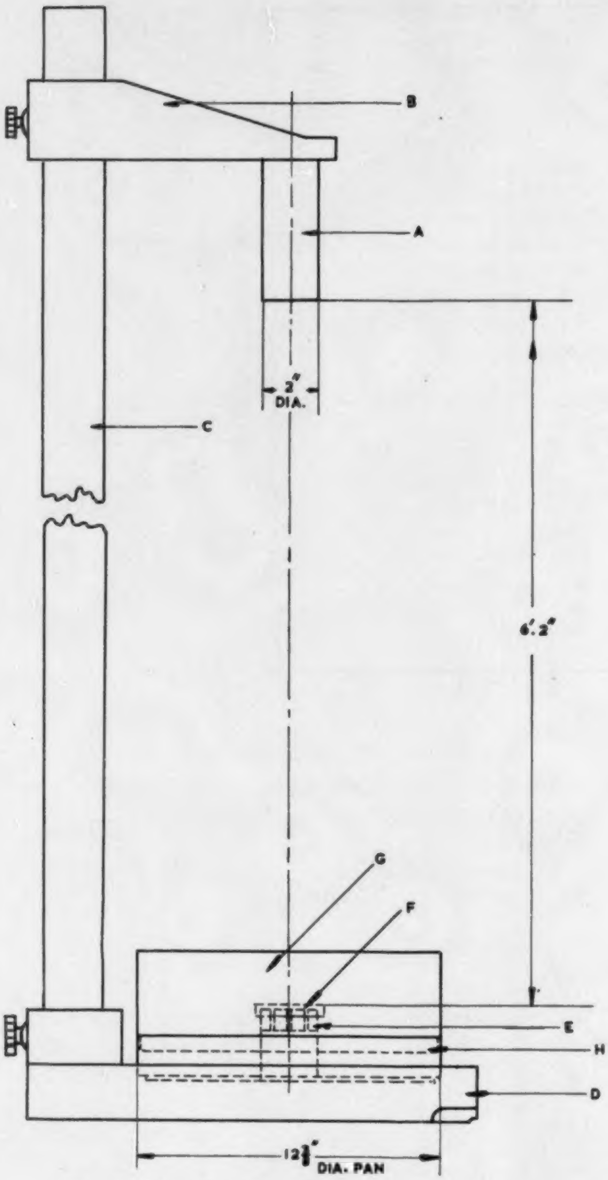


Fig. 8 — Apparatus for shatter test.

A–Stripping post.
B–Supporting arm.
C–Column carrying arm and post.
D–Base.
C–Anvil.
G–Sieve.
H–Pan.

In order to obtain a perpendicular fall of 6 ft, the height of the bottom of the stripping post above the top of the anvil is 6 ft 2 in.

The anvil must be firmly attached to the base and projects ½-in. through the center of the sieve. In order to ensure that the broken test piece falls onto the sieve clear of the anvil, the anvil head has a diameter of 3 in., this head being removable in order to facilitate removal of the sieve. Alternatively the anvil can be made in one piece and arrangements made to withdraw the pan and weigh the undersize, obtaining the oversize by difference.

The top of the supporting arm should be attached to a wall or other rigid body to prevent lateral movement of stripping post when carrying out the test.

Method of Testing. The standard AFS test piece is prepared by ramming with three blows in the recommended manner.

The test piece is then stripped by means of the stripping post on the apparatus. As soon as it is clear of the container it falls and strikes the anvil. The test piece shatters, and the broken pieces are collected and weighed. The cone of sand remaining on the head of the anvil is included in the oversize, i.e., it is transferred directly to the balance and is not first placed on the sieve. Care must be taken not to shake the sieve or some oversize fragments may be broken down and pass through the sieve.

A permissible alternative method of stripping is to hold the test piece contained on a suitable clamp and gently eject by means of plunger.

It is also permissible to collect and weigh the sand passing through the sieve, the oversize being obtained by difference.

The shatter index is the percentage by weight of the test piece which remains on the 0.5. in. sieve after testing in the above manner. The result reported should be the average of 3 tests, any which vary from the average by ± 5 per cent or more being ignored and the test repeated.

Precautions Necessary

1. The stripping post must be mounted so that it does not move while stripping is being effected.
2. The stripping post must be mounted so that its axis is vertical and its lower flat surface horizontal, and vertically above the center of the anvil. When stripping by means of a plunger, the movement must be slow since the test piece will otherwise acquire an appreciable velocity over and above that due to its fall.
3. The test piece must fall with its axis vertical so that the whole of its lower surface strikes the upper surface of the anvil at the same time, otherwise the test should be ignored.
4. The anvil must be rigidly attached to the base of the machine and must not merely rest on it or on the sieve. When a removable head is used this must be attached to the body.
5. The sieve must not be shaken. Unless both sieve and pan are kept in good condition unintentional shaking may occur when they are being separated, in which case erroneous results will be obtained.
6. Sands which are on the dry side are difficult to strip, particularly if they contain coarse grains. This may make the stripping operation difficult if it has to be carried out entirely by hand. On this account the use of a mechanically aided plunger or an air cylinder to push the test piece container over the stripping post is preferable.

Where such sands must be stripped by hand it is permissible to push the test piece partly out by means of a stripping post on the bench and complete the operation on the stripping post of the apparatus.

HIGH MANGANESE NICKEL ALUMINUM BRONZE CASTING CHARACTERISTICS

by G. Bradshaw, M. M. Kennedy and S. H. Dorn

ABSTRACT

The Philadelphia Naval Shipyard has long and varied experiences in the manufacture of propellers for combatant ships. The Navy, desirous of improving propeller performance and reducing weight, has many propellers in service for evaluation manufactured from nickel aluminum bronze.

A newly developed and patented nickel aluminum bronze alloy containing a high percentage of manganese is also purported to be desirable in propeller castings. Although considerable service data have been made available by the patent holder, the Bureau of Ships directed that its foundry and metallurgical characteristics be determined before any production castings were made for service evaluation.

This paper gives data obtained under conditions attainable with regular foundry practice for manganese bronze, revised to include procedures developed in casting nickel aluminum bronze. The characteristics of the alloy being investigated are compared with those of nickel aluminum bronze and manganese bronze cast under conditions considered normal and desirable for these alloys.

An investigation of the subject alloy was authorized to be conducted at the Philadelphia Naval Shipyard and was divided into two parts.

1) Investigation and development of foundry techniques such as gating, risering, fluidity, sensitivity to section size of mechanical properties, grain size, etc. This investigation has been completed and reported to the Bureau of Ships. The report is the basis of this paper.
2) Manufacture of propellers for service evaluation. A request has been made for authority to manufacture propellers for service study but has not been approved up to the time of this report.

The metal used was purchased in the form of ingots from the licensees. An equal quantity was purchased from each.

INTRODUCTION

Under the direction of the Bureau of Ships, Dept. of the Navy, a series of investigations were conducted by the Engineering Experimental Station, Annapolis, Md.,[1] to determine if possible a better propeller alloy than manganese bronze. The investigation covered subject alloy's strength, fatigue, corrosion-fatigue resistance and cavitation resistance. These results were compared to alloys used at present to manufacture ships propellers, and upon this basis were recommended that it should be given consideration as a good material for propellers.

One of the alloys used as a basis of comparison was nickel aluminum bronze. Many propellers, both for commercial and Naval use, have been made in this alloy. However, some difficulty has been experienced in casting these propellers since foundry techniques used in manganese bronze differ from those required to produce nickel aluminum bronze propellers of satisfactory quality.

In July 1958, the Philadelphia Naval Shipyard was authorized to conduct experiments to determine the foundry characteristics of subject alloy which would ultimately produce a satisfactory propeller for service evaluation. A typical composition of the new copper base alloy is approximately 12½ per cent manganese, 7½ per cent aluminum, 3 per cent iron and 2 per cent nickel.

To obtain melting stocks for conducting the various parts of this investigation, the equal quantities of metal received from each licensee was melted, thoroughly mixed, cast into ingots and used as a stock heat. The chemical and mechanical properties of the stock heat are given in Table 1.

While the composition of the stock heat, consisting of equal parts of the ingot metal supplied by the licensees, showed a slight deviation in iron and silicon contents from the specification limits, the variance was considered insignificant in view of the mechanical properties obtained. Therefore, this metal was used for the remainder of the investigation.

In melting the above heat, and for melting all heats used for the remainder of this investigation, oil-fired crucible pit furnaces were used. The analysis of the flue gases from the pits used is given in Table 2. This adjustment of the burners was maintained throughout the investigation.

Fludity vs. Pouring Temperature

The fluidity of subject alloy at representative pouring temperatures was determined by the use of a spiral mold designed and used by the U.S. Naval Research Laboratory (Fig. 2). Keel blocks for tensile

G. BRADSHAW is Master Molder, M. M. KENNEDY is in Engrg. (ret.) and S. H. DORN is Fdy. Met., Philadelphia Naval Shipyard, Pa.

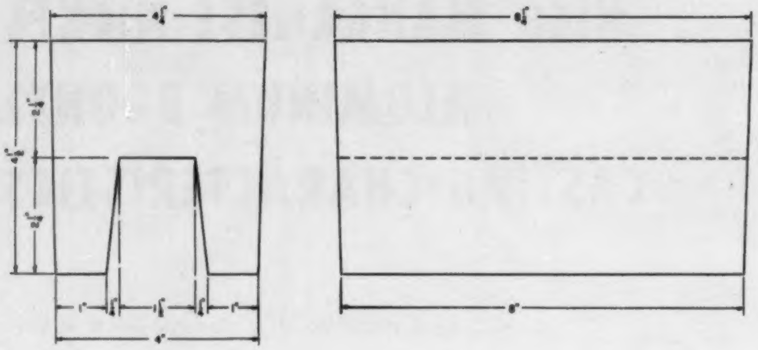


Fig. 1 — Dimensions of keel block used for tensile specimens.

TABLE 1 — PURCHASED INGOTS CHEMICAL COMPOSITION

	Composition, %					
	Cu	Al	Fe	Ni	Mn	Si
Vendor 1	75.13	7.75	3.00	2.43[a]	11.62[a]	0.07[a]
Vendor 2	75.00	7.60	2.85	2.18	12.37	0.01
Spec. Requirements Supplied by Vendors[2]	Rem.	7.50 / 8.00	2.50 / 3.00	1.80 / 2.20	12.00 / 13.00	Less Than 0.05
% Chemical Composition of Combined Purchased Ingots—Melted Into One Heat:	75.04	7.70	2.85	2.25[a]	12.10	0.06[a]

Mechanical Properties of Combined Purchased Ingots

	Yield Str.,[b] psi	Tensile Str., psi	Elong. in 2 in.,%
Avg. Four Specimens[c]	55,000	104,000	23.0
Spec. Requirements Supplied by Vendors[2]	40,000 min	90,000 min	20.0 min

NOTES: a. Not in accordance with vendors specification.
b. Yield strength at 0.005 in./in. under load.
c. Separately cast test bars, as shown in Fig. 1, using standard 0.505 in. diameter by 2 in. gage length specimen.

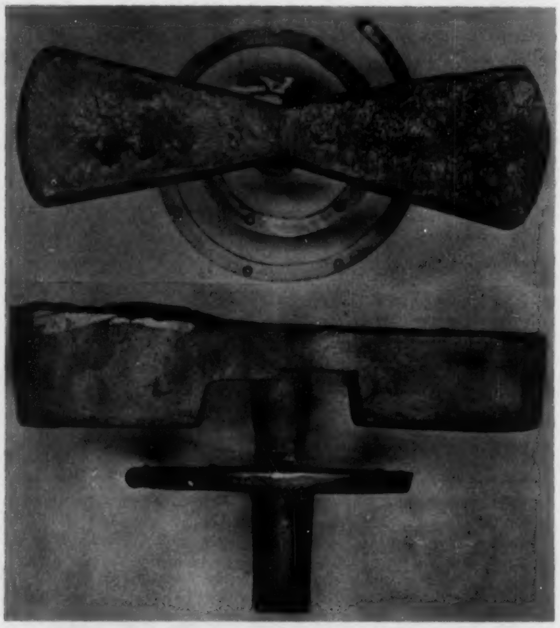


Fig. 2 — Spiral casting used in determining fluidity, showing head, gate and notches.

TABLE 2 — FLUE GAS ANALYSIS (ORSAT APPARATUS)

	Analysis, %			
Pit No.	CO_2	O_2	CO	N
2	14.4	0.2	1.6	83.8
3	12.0	0.2	4.4	83.4
4	14.0	0.0	1.4	84.6
5	15.2	0.2	0.0	84.6
6	13.6	0.0	2.8	83.6
7	14.8	0.4	0.8	84.0

test were cast at the same time as the fluidity spirals (Fig. 1).

The fluidity spirals and the keel blocks were cast in cement molds, having a moisture content of 6½ per cent as-rammed, and subsequently cured 20 days in the shipyard foundry. Similar tests were conducted using a nickel-aluminum bronze and manganese bronze for control. The results obtained are given in Table 3.

The data tabulated in Table 3 indicate that subject alloy at a temperature of 1900 F (1038 C) exhibits greater fluidity than manganese bronze at a temperature of 1800 F (982 C) and nickel aluminum bronze at a temperature of 2050 F (1121 C). The same conclusions were drawn when the fluidities of three above named alloys were compared at a temperature of 1975 F (1080 C), 1850 F (1010 C) and 2150 F (1177 C), respectively.

Since the fluidities of manganese bronze and nickel aluminum bronze at the temperatures indicated, both at the high and low temperatures are satisfactory for casting propellers, it was considered that the fluidity of the alloy being investigated would also be satisfactory at the indicated temperatures. Furthermore, this information could be used as a guide in establishing a recommended pouring temperature range for propeller castings.

However, in order to determine the effect of pouring temperature on the mechanical properties of the new alloy, keel block specimens were prepared in cement molds and pouring temperatures varied from 1750 F (954 C) to 1975 F (1080 C).

Mechanical Properties vs. Pouring Temperature

The mechanical properties were determined on standard 0.505 in. diameter, 2 in. gage length specimens. The cement molds had a moisture content of 6½ per cent as-rammed, and were cured 20 days in

TABLE 3 — FLUIDITY AND MECHANCIAL PROPERTIES vs. POURING TEMPERATURE

Pouring Temp., F	Spiral Length in.	Yield Point, psi[b]	Tensile Str., psi	Elong. in 2 in., %
High Manganese Nickel Aluminum Bronze				
1900	20.5	57,000	94,000	32.5
1975	33.5	58,000	93,000	31.5
Nickel Aluminum Bronze				
2050	14.0	40,000	90,000	27.5
2150	25.5	40,000	90,000	27.5
Manganese Bronze				
1800	16.5	Note[a]	71,500	31.5
1850	24.0		73,500	28.0

NOTES: [a] Specification does not require a yield point determination.
[b] Determined at 0.005 in./in. under load.

the foundry atmosphere. (Unless otherwise stated in the remainder of this paper, the above molding practice applies.) The results obtained are given in Table 4.

The high yield strength obtained in this part of the investigation could not be duplicated, nor is a reason for this offered. However, the results show indications of an increase of yield strength at the higher pouring temperature when casting keel block specimens.

Based on the data given in Tables 3 and 4, it was decided that a pouring temperature of 1900-1975 F (1030-1080 C) was most desirable for the alloy being investigated. This temperature range was used throughout the remainder of this investigation except as noted. Additional samples were cast into dry sand molds, baked sand molds and cement molds. The established pouring temperature range of 1900-1975 F (1030-1080 C) was maintained. The chemistry was adjusted to meet established minimum specification values. The results obtained are given in Table 5.

From the results obtained, it can be seen that subject alloy will meet the minimum mechanical values when melted to the minimum chemistry and poured into dry sand, baked sand and cement molds.

Drossing and Risering Characteristics and Sensitivity of Mechanical Properties to Section Size

In conducting this part of the investigation, two castings representing a propeller were cast. The basic pattern used to mold the castings is shown in Fig. 3. Seven days after the molds were made, they were coated with a graphite wash. One casting was made with a straight riser and the other with a tapered riser. An exothermic sleeve was incorporated in both riser cavities. Both castings were bottom fed using a by-pass or trap before the metal entered the mold cavity. The down gate and ingate were made from 2 in. diameter fire tile.

The two castings with gates and risers are shown in Figs. 4 and 4a. The sand practice was:

Washed silica sand AFS No. 50-70, lb	200
High early dry cement, lb	24
Water, lb	16.6
Mulling Time, min	7½

TABLE 4 — HIGH MANGANESE NICKEL ALUMINUM BRONZE MECHANICAL PROPERTIES vs. POURING TEMP.

Pouring Temp., F	Yield Str., psi[a,b]	Tensile Str., psi[b]	Elong. in 2 in., %[b]
1750	55,000	87,000	14.5
1750	55,000	78,500	10.0
1850	54,500	94,000	32.5
1850	55,000	94,000	31.5
1900	57,000	94,000	33.0
1900	57,000	94,000	32.0
1975	58,000	93,000	30.0
1975	58,000	93,000	33.0
1975	58,000	93,000	23.5
1975	58,000	93,000	30.0

NOTES: [a] Determined at 0.005 in./in. under load.
[b] Keel block specimens, see Fig. 1.

TABLE 5 — AVG. MECHANICAL VALUES FOR MINIMUM CHEMICAL SPECIFICATION LIMITS CAST IN VARIOUS TYPE KEEL BLOCK MOLDS

Mold	Yield, psi[a,b]	Tensile, psi[a]	Elong. in 2 in., %[a]
Baked Sand	43,200	91,600	32.0
Dry Sand	45,200	91,600	32.9
Cement	46,300	92,600	30.2

NOTES: [a] Values represent an avg. of six specimens.
[b] Determined at 0.005 in/in. under load.

Chemistry, %	Cu	Fe	Al	Mn	Ni	Si
Obtained	76.02	2.50	7.50	12.02	1.90	0.06
Desired	76.15	2.50	7.50	12.00	1.80	0.05 Max.

Black Graphite Wash	
Graphite, lb	100
Bentonite, lb	3
Dextrine, oz	3
Water, gallons	10½
Exothermic Sleeve	
Exothermic Material, % (as required)	93
Moisture, %	6
Bentonite, %	1
Mulling Time, min	3 to 5

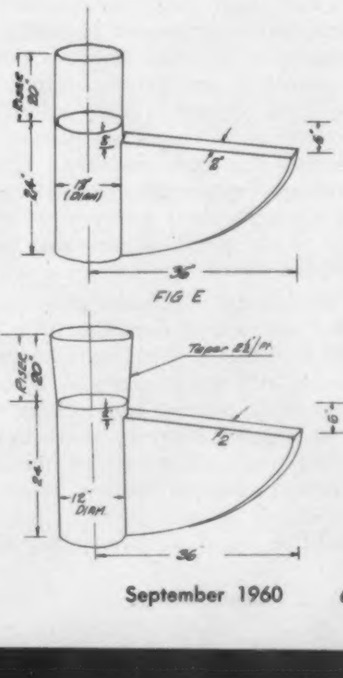


Fig. 3 — Drawing of simulated propeller.

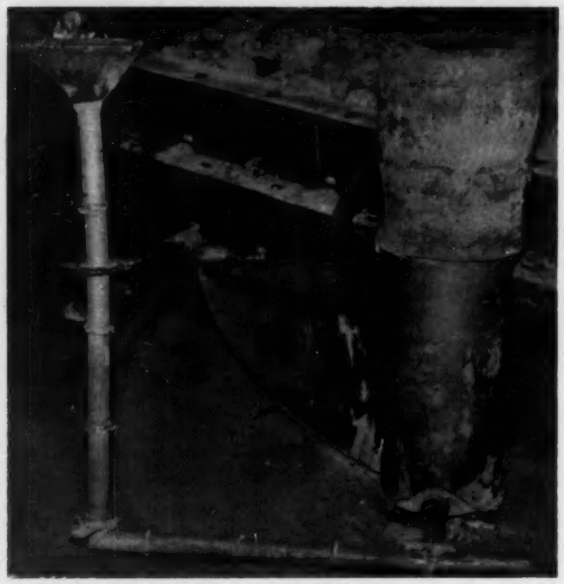


Fig. 4 — Simulated propeller casting, showing gating and risering with tapered riser.

Fig. 4a — Simulated propeller casting, showing gating and risering with straight riser.

To cast, the two simulated propellers required 4200 lb of metal. This metal was melted in oil-fired crucible furnaces. During melting, extensions were placed over the crucibles to prevent the flames from impinging on the metal. The composition of the furance atmosphere was determined with an atmospheric analyzer having a range of hydrogen 0-2 per cent and carbon dioxide 0-20 per cent.

The results obtained with this instrument indicated that none of the seven pit furnaces being used were operating under the slightly oxidizing condition recommended for this alloy. In attempting to correct the condition it was found that the burner equipment was incapable of adjustment to accomplish the desired results.

However, the furnace atmosphere under which the original ingots were melted was maintained. The metal was super heated to 2170 F (1188 C) and the contents of all seven crucibles poured into a ladle. A sample of the metal cast in a chill mold, when fractured, showed a dull woodlike fine grain indicative of a satisfactory silicon content and the absence of a gassy condition. Since the metal was considered satisfactory, the simulated propeller casting (straight riser) was poured when the temperature of the metal, as indicated by a pyrolance was 1950 F (1066 C).

The second simulated propeller casting (tapered riser) was poured from the same ladle (temperature 1925 F (1052 C). The risers of both castings were treated with equal quantities of exothermic hot top material. In pouring both castings the metal appeared to be sluggish. However, examination of the finished casting was indicative that the metal, as poured, possessed adequate fluidity. Examination of the as-cast surface of both castings, indicated a satisfactory condition equal to the surface obtained on nickel aluminum bronze and manganese bronze castings manufactured by regular foundry practice. The risers were removed from both castings and sectioned to observe their feeding and shrinkage characteristics.

Shrinkage Cavities

Photographs of the sections (Figs. 5 and 5a) show the shrink cavities obtained. The straight riser exhibits a greater sink cavity with less spongy metal in the adjacent lower section than the tapered riser. This difference may have been caused by the lower pouring temperature. The tapered risered casting was poured at 25 F lower than the straight riser.

The limited data observed from the two castings poured, do not permit any definite conclusion as to whether or not the straight riser is more efficient than the tapered one. However, it may be stated that both risers resulted in a satisfactory casting. This was further substantiated by sectioning and examining the simulated propeller castings.

The 24 in. hub portion was sectioned into three equal parts, and the outside surfaces were machined to a depth of 3/8-in. to determine the condition of the metal adjacent to the mold face. The finished machined hub sections are shown in Figs. 6 and 6a. Examination of the surfaces of the hubs after removing the 3/8-in. from the diameter, showed too little choice between the casting made using a tapered riser and the casting made using the straight riser. Both castings were considered about equal and representative of good surface conditions.

Mechanical Properties

The resulting mechanical properties were next evaluated. The hub sections were cut vertically, that sections representing the center, one half radius and outside of the 12 in. sections could be evaluated.

The standard 0.505 in. tensile specimen of 2 in.

gage length was machined from each of the vertical sections. The sections are referred to as bottom, center and top, indicating their respective positions in the propeller type castings when poured.

The blades which had been removed from the hub section were radiographed and vertically sectioned into three equal parts, sections were removed and standard 0.505 in. tensile specimens were machined from each section. These sections are referred to as blade near hub, middle of blade and blade near tip.

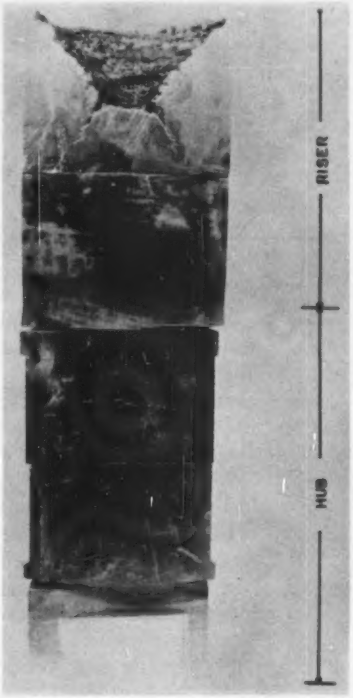
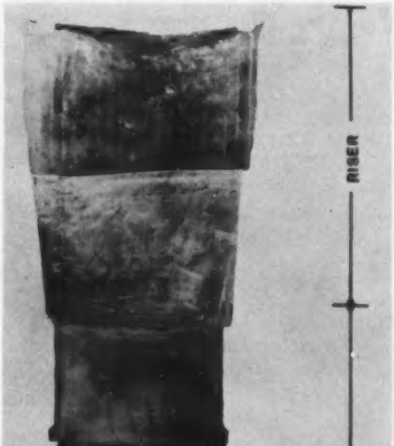
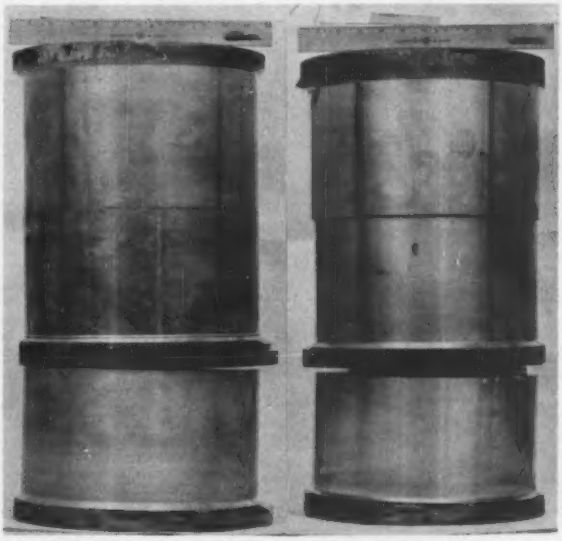


Fig. 5 — Simulated propeller casting straight riser.

Fig. 5a — Simulated propeller casting tapered riser.





Figs. 6 and 6a — Machined 12 in. diameter hub sections, ⅜-in. metal removed per side. Left — tapered riser; right — straight riser.

Fig. 7 shows the location of the samples in relation to the simulated propeller casting.

The resulting mechanical properties of a 2 in. section attached to a 12 in. section were then compared. These data could then be used to anticipate what type of mechanical properties could be expected if a propeller casting was manufactured from subject alloy. The results of these tests are given in Table 6.

Metallographic Examination

The results of metallographic examination of specimens taken from the simulated propeller show only a slightly coarser structure in the 12 in. hub section as compared with the 2 in. blade section. The photomi-

Fig. 7 — Position of specimens removed for mechanical property evaluation.

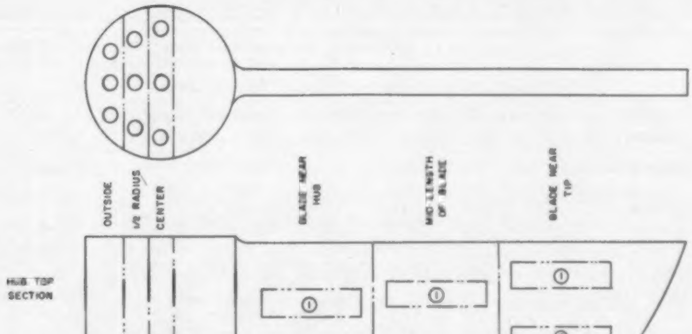


TABLE 6 — RESULTS OF TENSILE TEST SPECIMENS TAKEN FROM HUBS AND BLADES OF SIMULATED PROPELLER CASTINGS (FIG. 7) HIGH MANGANESE NICKEL ALUMINUM BRONZE

Location of Specimen	TAPERED RISER			STRAIGHT RISER			Location of Specimen	TAPERED RISER			STRAIGHT RISER		
	Yield, psi[a]	Tensile, psi	Elong., in 2 in., %	Yield, psi[a]	Tensile, psi	Elong., in 2 in., %		Yield, psi[a]	Tensile, psi	Elong., in 2 in., %	Yield, psi[a]	Tensile, psi	Elong., in 2 in., %
Hub-Bottom							**Blade Near Hub**						
Outside	40,000	81,000	23.0	40,000	83,500	23.5	1	45,000	83,000	20.0	45,000	81,500	20.5[b]
R/2	42,500	85,000	25.0	41,000	85,000	26.0	2	47,000	85,000	22.5	45,000	79,500	17.0[b]
Center	42,000	85,000	23.5	47,000	85,000	26.0	3	46,000	87,000	26.0	45,000	83,500	23.0[b]
							4	48,000	89,000	29.5	46,000	87,000	27.5
Avg.	41,500	87,300	23.8	42,700	84,500	25.2	Avg.	46,500	86,000	24.5	45,300	82,900	22.0
Hub-Center							**Blade Mid Section**						
Outside	45,000	81,500	24.0	44,000	79,000	19.5	1	50,000	88,000	21.5	42,000	84,000	18.5[b]
R/2	46,000	85,000	27.0	46,000	86,000	27.5	2	52,000	89,500	22.5	44,000	81,000	15.0
Center	44,000	81,000	30.5	43,000	83,000	24.0	3	50,000	88,000	21.0	43,500	88,500	25.0
Avg.	45,000	82,500	27.2	44,300	82,700	23.7	Avg.	50,700	88,500	21.7	43,200	84,500	19.5
Hub-Top							**Blade Near Tip**						
Outside	42,000	64,000	9.5[b]	44,000	89,000	25.0[b]	1	48,000	93,500	20.5	43,000	87,000	16.0
R/2	43,000	67,000	6.0[b]	45,000	83,500	21.5[b]	2	50,000	92,500	20.0	51,000	89,000	18.0
Center	43,000	76,500	17.5[b]	45,000	74,000	13.5[b]							
Avg.	42,700	69,200	11.0	44,700	82,200	20.0	Avg.	49,000	93,000	20.3	47,000	88,000	17.0

NOTES: a) Determined at 0.005 in./in. under load.
b) Defective specimens.

crographs of the hub and blade sections are shown in Fig. 8.

The mechanical properties of the tapered risered vs. the straight risered casting was given in Table 6. To make a more complete evaluation of subject alloy, a simulated propeller casting of nickel aluminum bronze and keel block specimens were made and used as a basis of comparison of the two alloys. This procedure resulted in the evaluation of similar type specimens. The same pattern, molding procedure and melting condition as that used in manufacturing the simulated propellers of the subject alloy were followed.

The straight riser was used for the nickel aluminum bronze, therefore the resulting properties are compared with the straight riser casting of the subject alloy. Table 7 shows these data, and a comparison of comparable sections of subject alloy and nickel aluminum bronze. Table 8 summarizes the values of Table 7, and gives values to compare the average values resulting in the 12 in. hub section, the 2 in. blade section and keel block samples of the above two alloys.

In order to further compare the characteristics of subject alloy under the conditions of free fall, a condition existing in propeller casting practice, keel block molds were prepared to determine this effect upon the mechanical properties of nickel aluminum manganese alloy.

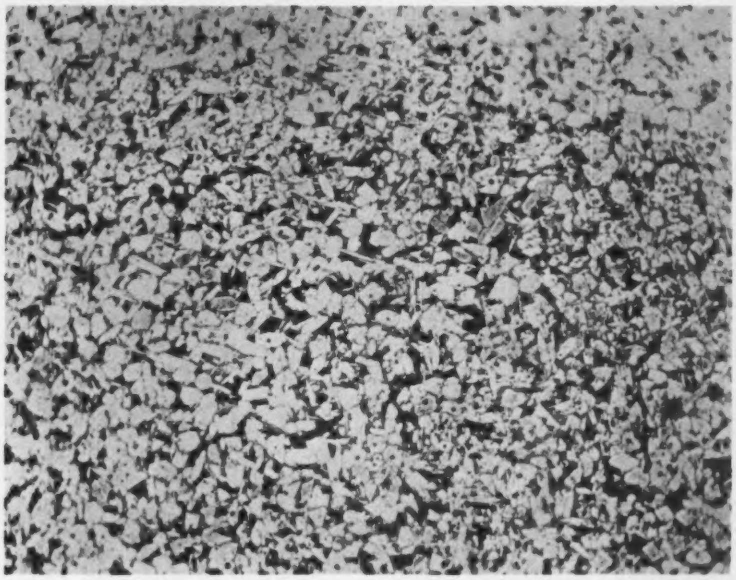
The same procedure was carried out using manganese bronze and nickel aluminum bronze. Two keel block molds of each alloy were prepared for this part of the investigation. In one keel block, the height of the pouring gate was equal to depth of the coupons, plus the depth of the riser, a drop of 4 in. The other mold was similar in all respects, except that the pouring gate was 24 in. longer, or a total of 28 in. (Fig. 9).

TABLE 7 — COMPARISON OF MECHANICAL PROPERTIES OF HIGH MANGANESE ALUMINUM BRONZE WITH COMPARABLE TYPE SPECIMENS OF NICKEL ALUMINUM BRONZE

Propeller Casting (Simulated) Straight Riser

Location of Specimen	High Mn-Al Bronze—Hub			Ni-Al Bronze—Hub			Location of Specimen	High Mn-Al Bronze—Blade			High Ni-Al Bronze—Blade		
	Yield, psi[a]	Tensile, psi	Elong., in 2 in., %	Yield, psi[a]	Tensile, psi	Elong., in 2 in., %		Yield, psi[a]	Tensile, psi	Elong., in 2 in., %	Yield, psi[a]	Tensile, psi	Elong., in 2 in., %
Hub-Bottom							**Blade Near Hub**						
Outside	40,000	83,500	23.5	37,000	79,500	20.0	1	45,000	81,500	20.5	38,000	79,000	19.0
½ Radius	41,000	85,000	26.0	37,500	80,000	23.0	2	45,000	79,500	17.0	36,000	77,000	18.0
Center	47,000	85,000	26.0	36,500	82,000	24.5	3	45,000	83,500	23.0	38,000	83,000	22.0
							4	46,000	87,000	27.5	40,000	78,000	17.5
Avg.	42,700	84,500	25.2	37,000	80,500	22.5	Avg.	45,300	82,900	22.0	38,000	79,300	19.1
Hub-Center							**Blade Mid Section**						
Outside	44,000	79,000	19.5	38,500	79,000	20.0	1	42,000	84,000	18.5	41,000	81,000	15.0
½ Radius	46,000	86,000	27.5	38,500	80,000	21.0	2	44,000	81,000	15.0	40,000	83,500	17.5
Center	43,000	83,000	24.0	38,500	78,000	18.0	3	43,500	88,500	25.0	40,000	73,000	9.5
Avg.	44,300	82,700	23.7	38,500	79,000	19.7	Avg.	43,200	84,500	19.5	40,300	79,200	14.0
Hub-Top							**Blade Near Tip**						
Outside	44,000	89,000	25.0	43,000	77,500	16.5	1	43,000	87,000	16.0	41,000	83,000	16.5
½ Radius	45,000	83,500	21.5	40,000	77,500	16.0	2	51,000	89,000	18.0	40,000	85,000	17.5
Center	45,000	74,000	13.5	36,500	73,500	18.0							
Avg.	44,700	82,200	20.0	39,800	76,200	16.8	Avg.	47,000	88,000	17.0	40,500	84,000	17.0

NOTE: a) Determined at 0.005 in./in. under load.



Blade tip of simulated propeller, 2 in. thick.

Centerline of hub of simulated propeller casting, 12 in. diameter.

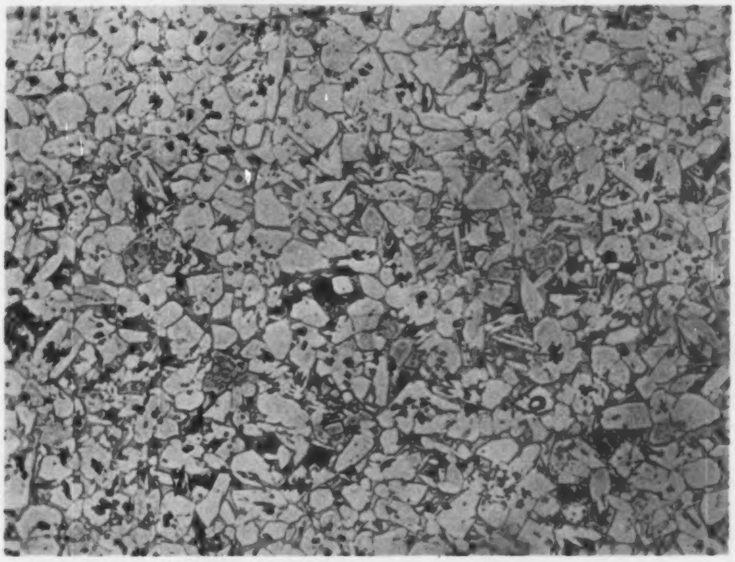


Fig. 8 — Photomicrographs of blade (top) and hub (bottom) of simulated propeller casting. Etch: 3 parts acetic acid, 75%; 2 parts nitric acid, con.; 3 parts acetone. 75 ×.

The resulting Mechanical Properties are given in Table 9.

The results shown in Table 9 indicate that a slight reduction occurs in the mechanical properties with nickel aluminum bronze, manganese bronze and subject alloy when the pouring gate is 24 in. greater than normal.

CONCLUSIONS

Based on the results obtained in this investigation, it is concluded:

Mechanical Properties. Based on the results obtained from keel blocks specimens the yield point of subject alloy is about 7500 psi greater than that of nickel aluminum bronze, and is only slightly superior with respect to ultimate tensile strength and about equal in ductility, the latter as measured by the per cent elongation values of the test bars.

Based on a comparison of results obtained from a 2 in. blade section attached to a 12 in. diameter by 24 in. high hub, the yield of subject alloy was found to be 5500 psi greater than nickel aluminum bronze in the 12 in. section and 5700 psi greater in the 2 in. section. The ultimate tensile was also slightly superior, but the elongation values were comparable.

Subject alloy will meet the minimum mechanical values when melted to the minimum chemistry poured into dry sand, baked sand and cement molds.

Gating, Drossing and Fluidity. The fluidity of subject alloy was found to be satisfactory at a pouring temperature of 1900 F (1030 C) and 1975 F (1080 C),

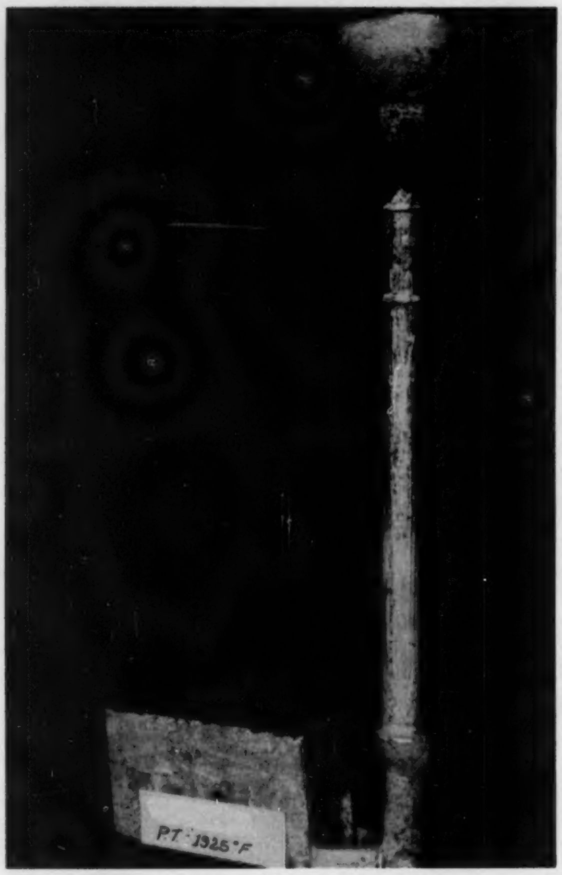


Fig. 9 — Keel block with 24 in. downgate.

TABLE 8 — COMPARISON OF MECHANICAL PROPERTIES OF SUBJECT ALLOY WITH COMPARABLE TYPE SPECIMENS OF NICKEL ALUMINUM BRONZE

Type of Specimen	Alloy	Tensile, psi	Yield, psi[d]	Elong., in 2 in., %
Cement Bonded Keel Block[a]	Mn-Ni-Al Bronze	49,500	92,400	24.1
Cement Bonded Keel Block[a]	Ni-Al-Br	41,400	90,000	26.1
Simulated Propeller				
12 in. Hub[b]	Mn-Ni-Al Bronze	43,900	83,100	22.9
12 in. Hub[b]	Ni-Al-Br	38,400	78,500	19.7
2 in. Blade[c]	Mn-Ni-Al Bronze	45,000	84,500	16.3
2 in. Blade[c]	Ni-Al-Br	39,300	80,300	16.9

NOTES: a) Avg. of 6 specimens.
b) Avg. of 9 hub specimens of Table 7.
c) Avg. of 9 blade specimens of Table 7.
d) Determined at 0.005 in./in. under load.

Chemistry of simulated propellers and keel blocks, %

Alloy	Cu	Fe	Al	Mn	Ni	Mg	Si
Ni-Al-Mn-Bronze	75.04	2.85	7.70	12.10	2.25	—	0.06
Ni-Al-Bronze	81.54	3.96	9.00	0.54	4.68	0.20	—

TABLE 9 — MECHANICAL PROPERTIES OF KEEL BLOCK SPECIMENS CAST WITH POURING GATES OR NORMAL HEIGHT (4 IN.) AND WITH POURING GATES 24 IN. GREATER THAN NORMAL

Material	Height of Pouring Gate, in.	Yield., Str., psi	Tensile Str., psi	Elong., in 2 in., %	Pouring Temp., F
Manganese Nickel Alum. Bronze	Normal 4	51,000 50,000	97,000 96,500	27.5 28.0	1950
Manganese Nickel Alum. Bronze	24 greater than normal 28	50,000 50,000	97,000 97,000	31.5 30.0	1950
Nickel-Alum Bronze	Normal	41,500 41,000	90,000 90,000	26.5 26.0	2060
Nickel-Alum Bronze	24 greater than normal	41,000 41,000	87,500 87,500	19.5 19.5	2060
Manganese Bronze	Normal	—	73,000 73,000	28.0 28.5	1850
Manganese Bronze	24 greater than normal	—	71,300 72,000	28.5 25.5	1850

NOTE: Determined at 0.005 in./in. under load.

respectively, when compared to nickel aluminum bronze at a temperature of 2050 F (1121 C) and 2150 F (1177 C) and manganese bronze at a temperature of 1800 F (982 C) and 1850 F (1010 C). Thus, it cast satisfactory at a temperature slightly in excess of that used for manganese bronze and somewhat less than that used for nickel aluminum bronze.

Gating and risering in casting subject alloy indicates that it possesses many characteristics exhibited by nickel aluminum bronze and should be subject to the same precautions used in gating and risering nickel aluminum bronze. In drossing the subject alloy appears to be approximately equal to nickel aluminum bronze.

Sensitivity to Section Size. The mechanical properties decrease as the section size increases. However, the loss is about equal to nickel aluminum bronze and is not considered excessive. Futhermore, the subject alloy exhibits only a slight increase in grain size as the section increases from 2 in. to 12 in.

Chemical Impurities—Silicon Content. The manufacturers of the subject alloy have stated that the silicon content of this alloy must be held to 0.05 per cent maximum. The experimental tests run in this investigation were melted in silicon carbide crucibles without evident effect upon the resulting mechanical properties or silicon pickup. However, what per cent silicon pickup or detrimental effect would result from melting a 45,000 lb charge in the foundry's silica lined reverboratory furnace cannot be answered at this time.

No welding tests were performed as this was out of the scope of this investigation.

REFERENCES

1. "Superston 40 Bronze Propeller Alloy—Research and Development," Report 040096 - NS - 013 - 118, H. C. Ellinghausen, Mechanical Met. Branch U.S. Naval Eng. Exp. Station, Annapolis, Md. (March 8, 1957).
2. "Properties of Superston 40 Bronze — Adapted from reference M," J. Stone & Co. Ltd. (March 21, 1955).

QUALITY ACID STEEL PRACTICE ECONOMICS

by C. F. Christopher

ABSTRACT

A general discussion of the principles involved in the manufacture of good steel castings economically is presented. Such items are included as 1) selection of the proper process acid or basic; 2) difference in cost of production of acid and basic steels made in the cold metal process; 3) discussion of the proper furnace design, atmospheric conditions, speed of melting, selection of scrap, etc., for the manufacture of good acid steel; 4) some of the chemistry differences between acid and basic steel making, and why a difference in deoxidation is necessary; 5) some of the theories of deoxidation which are important and necessary to know if we wish to deoxidize properly and economically and 6) are expensive special or complex deoxidizers necessary or can the same result be obtained by simple deoxidation.

INTRODUCTION

The manufacture of steel for various products under present day economic conditions requires a careful evaluation of all phases relating to that manufacturing practice. All products that are manufactured must meet a given standard of quality. This quality standard can be defined as one that produces castings suitable for the purpose intended, gives reasonable service in the field and can be manufactured and sold at a reasonable profit.

The quality standard for any one product or all products is steadily increasing as more is learned about the business, but it is controlled chiefly by those companies which have the greatest know how, by those which know how to increase quality without increasing manufacturing costs and those which know the most about the adaptation of fundamental technical knowledge to any particular product being manufactured.

Quality standard is not directly proportional to the price per pound received for the products. For survival the quality standard of the best producers must be kept up with and retained. Present business will be retained and new business gained only if these standards are kept up.

STARTING POINT — QUALITY

Since the standard of quality is the uncontrollable starting point, profit is controlled entirely by the cost of production. In other words, quality standards hold and make business, while sound operating costs make and control profits.

The author's company is one of the largest producers of steel castings, mill equipment and other diversified products. The bulk of the steel produced in this company is manufactured by the acid open hearth process, a lesser amount of specialized steels being produced in acid electric. This company produces castings from 10 lb to 300,000 lb in weight, a wide variety of alloy compositions and carbon contents from 0.15 per cent to 3.00 per cent. No one will question the rigid quality standard requirements on steel rolls, armor castings, die castings, wear resistant steels, excavating machinery, rock crushing equipment and many others.

The manufacture of this great diversification of products means that the company must select the correct steel making process, the best furnace design possible, the best fuel and furnace atmospheric control, the most fundamental deoxidation practice, the best knowledge of size and type of scrap and raw material selection as well as the ability to apply fundamental knowledge of steel making over a wide variety of conditions.

Many years ago a large percentage of the world's steel was produced in the acid open hearth. Today only approximately one per cent is thus produced. Much of this decline in acid steel was due to the advent of the automobile, etc., which consumes large tonnages of rimmed and other low carbon steels unadaptable to acid production. However, many of the medium carbon, forging and higher carbon grades have changed from the acid to the basic process. It is on these grades that the economics of steel making practices should be discussed.

There are many diversified opinions on the type of practice most suitable to steel making in individual plants. This disagreement exists for many reasons, some of which are legitimate and many are incorrect due to lack of sound information on the true merits of both practices.

When discussing or evaluating various practices adaptable to the manufacture of steel castings there are two equally important factors to consider. One is the cost of production and the other is the quality of the product. Is it possible to select the cheapest

C. F. CHRISTOPHER is Chief Met., Blaw-Knox Co., East Chicago, Ind.

process and produce equally good quality by altering our operating methods and deoxidation practices?

ACID VS. BASIC STEEL

A good physical quality basic steel is relatively easy to produce because it can stand certain degrees of over deoxidation without completely destroying its properties. This is primarily due to its relatively low sulfur content. On the other hand, no mistakes of deoxidation are permissible in acid steel making. Its sulfur content is high and its oxidation characteristics highly variant and highly dependent upon scrap charge, furnace conditions, operating personnel and speed of refining.

The oxygen system in basic operation greatly increases from the time the heat is charged until it is ready to tap. An acid open hearth has the reverse system, which means that ample oxidation in the system is almost completely dependent upon type of charge, amount of rust on scrap, type of atmosphere and sharpness of furnace. The type and amount of deoxidation on an acid is critical and must be scientifically controlled, due to the lower oxygen level and the higher sulfur content.

Some of the reasons why acid steel production has decreased over the years are:

a) Overworking of heats and belief that green slags were required.

b) Improper or lack of sound deoxidation knowledge.

c) Belief that clean selected scrap was necessary.

d) Assumption that acid steel was not a high production process and therefore not enough attention paid to the development of sharp, highly oxidizing furnaces which we now believe are necessary.

e) The erroneous belief by many that physical defects in castings are a steel making responsibility. This belief exists more in acid steel making that in basic, probably due to the existence of more phosphorus and sulfur contents.

Whether steel quality is affected by acid or basic practices is a controversial subject. There is no question but that lower phosphorus and sulfur in the basic practice should have a positive effect on quality as measured by physical testing. However, a true measure of quality is much more complicated and involves more than the mere increasing of physical property results.

The definition of quality as given by a research director and that given by a stockholder are worded much differently. That given by the stockholder will not stress physical properties as an ultimate, but rather, a product which is acceptable to the industry—one that can be made economically. It is just as foolish to over stress quality at the expense of economy as it is to over stress economy at the expense of quality. It is the writer's opinion that this discussion of steel making practices, therefore, should include other comparative considerations which could affect economics through the cleaning room, furnace maintenance, etc.

There are technical differences between acid and basic operating practices which are of major importance. Although these technical differences are universal wherever the practices are used, their importance depends upon type of product and many other conditions. In basic steel making, there are many types of practices, such as cold metal charges, duplex practices, hot metal practice, etc., which can not be compared with cold metal acid steel making unless it is done on the same basis. The author's company, for instance, would be interested in comparisons based upon cold metal charges. They are interested in cost per ton differentials of cold metal practice while maintaining a satisfactory quality standard.

Basic Cold Metal Practice

It always requires more pig iron to produce a basic heat of a given carbon content, than it requires in an acid furnace. The reason being that all basic irons must be low in silicon since any silicon present will quickly attack basic bottoms and slag-making materials.

In the absence of silicon, there is nothing to protect the carbon. The carbon, therefore, eliminates during the melt down period and the refining period readily. In order to compensate for this freedom of carbon elimination, basic heats must be charged higher in pig iron so that there is enough carbon left after the heat is melted to refine the bath and acquire adequate temperature.

As the carbon specification requirement increases, more and more pig iron percentages are necessary.

Acid Cold Metal Process

The acid process is an economical one as far as pig iron consumption is concerned. The main reason being that silicon pig can be used without destroying the bottom. This silicon content conserves carbon by destroying oxidation during melting. Conversely to the basic, the higher the carbon specification, the more efficient the pig iron becomes, because more silicon is available.

The approximate comparative pig iron requirements of acid vs. basic cold metal practices are (depending somewhat upon type of scrap available):

Carbon, %	Acid Pig, %	Basic Pig, %
0.30	12	27 to 35
0.50	15	35 to 40
0.80	25	50 to 55
2.00	38	80

Oxygen Practice

The basic industry takes advantage of this high pig iron consumption by what is known as the

"Oxygen Process." In basic cold metal practice the melting carbon is somewhat erratic. Some of the heats melt high. By introducing jets of oxygen or enriched air, this excess carbon can be rapidly eliminated.

In most hot metal shops, it has been found that the basic process can be cheapened by charging even higher percentages of liquid pig iron and blowing it down with oxygen. The iron is already at about 2500 F, which greatly speeds up the time required to bring the bath to a refining temperature. The excess carbon is then blown out with oxygen in a short time.

It is therefore cheaper to charge liquid pig iron at 2500 F up to 80 per cent or higher, and blow out the carbon than to attempt to save hot metal and use cheap scrap. In other words, saving time is cheaper than material economy.

Basic vs. Acid Charges

There are two general types of pig iron used in the acid practice, namely, bessemer, a medium phosphorus pig, and low phosphorus pig. The proper selection depends upon the type of scrap available. The sulfur content of these two irons are about the same level.

The price of acid bessemer pig and basic cold irons are similar. When low phosphorus iron is necessary in the acid furnace, the cost of the acid practice increases due to the high price of this iron.

It is interesting to set up a comparative cost sheet between acid and basic cold metal charge, assuming that both were used in the manufacture of castings in a shop similar to the author's company.

Although scrap prices fluctuate considerably from month to month, the following prices were taken from *Iron Age* as of June 1, 1959:

ACID		BASIC	
Charge	Cost/ton	Charge	Cost/ton
Plate	43.50	R.R. heavy melt	37.50
Forge	46.50	No. 1 heavy melt	32.50
Wheels	44.50	No. 2 heavy melt	30.50
High silicon bundles	39.50	No. 2 bundles	22.50
Bessemer pig	67.00	basic pig	66.00
	at producing point		at producing point.

If basic or acid practice were used in one foundry, the heads, gates, etc., would be called home scrap or returns, and would be the same price in either case. We are assuming a common price of $40.00/ton in either case.

In the manufacture of 0.30 carbon steel castings, taken as an example, the following average metallic charges would probably be used.

ACID		BASIC	
Charge	%	Charge	%
Pig Iron	12	Pig Iron	27
Domestic	50	Domestic	50
Purchased	36	Purchased	21
Additions	2	Additions	2
	100		100

COMPARATIVE COSTS OF METALLIC CHARGES

Charge		Cost/ton
Acid (with bessemer pig)		
Pig Iron	12% x $67.00 =	8.04
Domestic	50% x $40.00 =	20.00
Purchased	36% x $43.50* =	15.66
	Avg. Cost per Ton	43.70
Acid (with low phosphorus pig)		
Pig Iron	12% x $71.00 =	8.52
Domestic	50% x $40.00 =	20.00
Purchased	36% x $43.50* =	15.66
	Avg. Cost per Ton	44.18
Basic Practice		
Pig Iron	27% x $66.00 =	17.82
Domestic	50% x $40.00 =	20.00
Purchased	21% x $30.75* =	6.46
	Avg. Cost per Ton	44.28

* Avg. purchased scrap — cost per ton.

It can be seen that the cost of the metallic charges of acid and basic in cold metal operation are relatively close, contrary to general belief. The fact that the basic furnace requires a larger percentage of pig iron than the acid, minimizes or counteracts the cheapness of basic scrap. Even the use of low phosphorus pig does not materially upset the relationship due to the small amount required to make acid heats.

It must be remembered that in a foundry such as the author's company's, the domestic scrap has to be utilized at a rate of about 50 to 40 per cent of the charge. This fact minimizes the amount of cheap scrap, such as No. 2 bundles, etc., which can be used in a basic practice foundry.

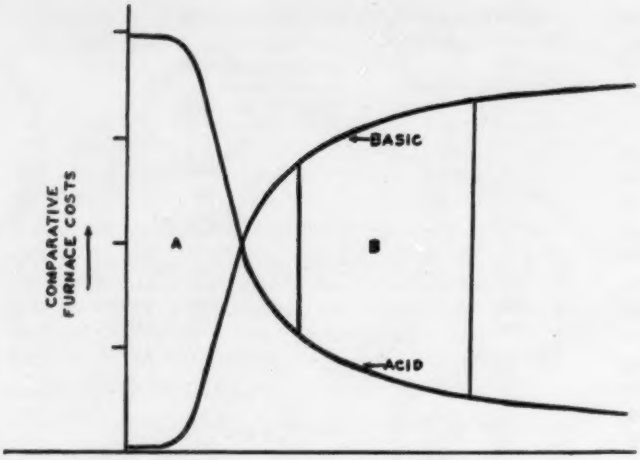
The cost of basic increases faster than acid when higher carbon steels are to be cast. An 0.80 per cent carbon steel, for instance, would work out about as follows:

0.80% Carbon Steels

Charge		Cost/Ton
Acid Practice — (Bessemer Pig)		
Pig	25% x $67.00 =	16.75
Domestic	50% x $40.00 =	20.00
Purchased	23% x $43.50 =	10.00
	Avg. cost per ton	46.75
Basic Practice		
Pig	50% x $66.00 =	33.00
Domestic	48% x $40.00 =	19.20
	Avg. cost per ton	52.20

OPERATIONAL COST COMPARISON

The basic open hearth is primarily adaptable to the manufacture of low carbon steel. As has been previously shown, it gradually loses this economy as the carbon content of the steel increases, but that



Combined furnace and operating cost differentials between acid and basic steel making practice.

this higher cost is minimized by hot metal, duplex and oxygen injection practices.

However, the basic furnace further presents the problem of furnace erosion which far exceeds that of acid practice. Under good operational conditions, the best average life of a basic furnace is approximately 400 heats. The life of an acid furnace almost entirely depends upon the skill of the operator, and will average from 400 to 1600 heats. The ladle life is approximately four to one in favor of acid. The average life of the furnace and ladle at the author's company is about 1500 and 60, respectively.

When the differential costs of metallic charges and furnace life are combined, one can see just when it pays to use and when not to use certain type furnace practices. To this must be added the extra cost of lime, fluorspar, scale, etc., which are needed to operate a basic as compared to sand alone in the acid practice.

The figure shows diagrammatically the combined furnace and operating cost differentials between acid and basic. As can be seen by the figure, the cost of acid steel is tremendous in the low carbon steels, whereas the basic is cheap, comparatively.

Area *A* represents rimmed, semi-killed and other steels under 0.20 per cent carbon. It is practically impossible to get an acid heat down below 0.09 per cent carbon, whereas a basic furnace can charge low pig percentages and load the furnace up with cheap scrap and can lower the carbon down to 0.01 per cent carbon or less.

However, as soon as an acid furnace gets into a carbon range which it can make, its comparative cost drops rapidly, due mainly to its long furnace life.

Area *B* is the higher carbon ranges where acid is cheaper than basic. At some carbon content the comparative costs of metallic charges and furnace life are equal in the two practices. At the author's company the costs balance at about 0.20 per cent carbon. In making 0.20 per cent carbon steel in an acid, the tapping carbon would have to go down to possibly 0.10 to 0.12 per cent in most cases to be able to use regular chromium and manganese additions, unless more expensive low carbon chromium and manganese were used. This low tapping carbon lengthens the time on heats and destroys some of the good furnace life of the acid furnace.

However, as soon as an acid furnace is able to operate normally, its comparative cost drops rapidly. In acid shops which do not get good furnace life, either due to type of product, poor furnace design or for other reasons, the carbon location where the acid becomes cheaper will increase. For instance, at some acid plants the average furnace life of the acid is around 400 heats, less than one-quarter of that at the author's company. It is, therefore, possible that it may pay them to install basic practice, even though a major part of their steel is around 0.30 per cent carbon. It would not pay to do this at the author's company, because the costs are better than basic above 0.20 per cent carbon chiefly due to 1600 heat furnace life.

Everyone realizes the excessive cost of making low carbon acid or high carbon basic. However, most foundries debate the point where the costs of operating these two practices cross each other, since most castings are around 0.30 per cent carbon. It is important to stop and take all factors into consideration before making decisions. When acid furnaces last 1600 heats, it takes a lot of quality improvement from the basic steel making operating to make a basic furnace pay off. This is particularly true after the fact is recognized that most casting defects, such as hot tearing, shrinkage, etc., are physical defects common to both acid and basic, and only eliminated by scientific heading and gating and foundry's know how.

The excellent job being done at the author's company on furnace operation, together with the metallurgical practice being used, which combats the ill effect of sulfur, makes acid steel competitive beyond reach in the company.

FLUIDITY AND ITS SIGNIFICANCE

Acid steel naturally has some unfavorable characteristics, but most of these conditions can be offset with some little thought.

Acid steel furnaces have tremendous life which makes its operating costs cheap. How can this good feature be retained, and offset the effects of phosphorus and sulfur which are reputed to be the main barriers?

Phosphorus, contrary to popular belief, is what makes acid steel the fine product that it is. If acid steel did not contain phosphorus, the author would not be able to write this paper highly in its favor. The fact that acid steel contains phosphorus, and plus the fact that acid slag in the ladle is so refractory that it holds ladle temperature over longer periods of time than basic slag, makes it possible to produce high quality, low cost products.

Phosphorus produces fluidity which can be retained over long pouring periods with the help of a refractory acid slag covering the metal in the ladle. This fluidity characteristic allows acid steel to be tapped and poured at lower temperatures and, consequently, deoxidized with silicon alone which is a weak deoxidizer, which is the compensating factor in combatting sulfur.

With silicon deoxidation alone, steel is susceptible to porosity above 2850 F pouring temperature.

The fluidity and rate of temperature loss in an acid heat allows a 2850 F pouring temperature to pour a considerable length of time. A basic heat poured at 2850 F will become sticky in much less time. In order for a basic heat to pour approximately as long as the acid, it must be poured hotter to begin with, possibly 50 F hotter. This excessive temperature above 2850 F requires that aluminum be added, as known.

If one large casting were poured, for instance, where the pouring would only cover a few minutes, both acid and basic heats could be poured low and the same temperature. In longer pouring operations the basic has to compensate for lack of fluidity by increasing pouring temperature which requires aluminum deoxidation.

Phosphorus in acid steel, therefore, allows low temperature, weak deoxidation for the important job of combatting sulfur. This makes acid steel competitive to basic in quality plus the factor of high furnace life.

ACID AND BASIC QUALITY

This paper does not pertain to research, but is written to acquaint everyone with the two practices in question. It is a conclusion that basic quality, as detected by physical tests, is at a slightly higher level than acid steel. However, the best practice is always the one that has the most dollars left.

Another undesirable characteristic of acid steel making is the strong affinity of acid slags for manganese. It is not uncommon, when manganese is added to the furnace, to lose from 20 per cent on higher carbon grades, to 50 per cent on low carbon grades. Furthermore it is difficult to maintain a great degree of consistency. This inconsistency is particularly true if an attempt to speed up production with sharp furnace operation and fast melting is made, an operating condition which is naturally more economical and is believed by many to give the best acid product.

In order to acquire any degree of consistency in manganese when added to the bath, the addition must be made with a uniform lump size, and the heats must be tapped almost with stop-watch timing. Delays in tapping fast and slow taps or any variation of slag viscosities all affect the final manganese.

Research in steel making should serve a two-fold purpose. It first tells us what happens chemically and thermodynamically under given temperature conditions. Secondly, it should tell us if and how we can readjust our practices to a more economical one. There is nothing in the field of thermo-chemistry which says that any addition has to be made in the furnace. As far as the metal is concerned, the same thermo-chemical reactions occur, at a specific temperature, whether that metal is in the furnace or in the ladle. The only problem of adding manganese to the ladle is a physical one, that of getting it thoroughly melted and uniformly mixed.

Silico-manganese is a fast melting manganese alloy at normal steel making temperatures. Under proper condition this alloy could be safely added to the ladle. The author's company manufactures an automatic ladle feeder system which adds ladle additions at any desired speed. This equipment automatically weighs and feeds at any rate desired by the operator. When silico-manganese is added to the ladle the efficiency consistently exceeds 90 per cent, as compared to an average of 72 per cent for ferro or silico-manganese added to the furnace.

There is not much difference in cost between the practice of using silico-manganese or ferro-manganese plus 50 per cent silicon. However, since we are discussing the economy of ladle vs. furnace additions and recommend silico-manganese, crushed, as a ladle addition, the following is an example of how this practice would affect costs.

The foundry in question makes approximately 2000 tons of castings per month with manganese contents ranging from 0.60 to 1.25 per cent.

1) Avg. amount of silico-manganese added in furnace/month, lb	89,000
2) Avg. amount of ferro-manganese added in furnace/month, lb	77,000
3) If ferro-manganese were converted to silico-manganese avg. amount added in furnace/month, lb	87,010
4) If all manganese were added as silico-manganese to the furnace. Amount added/month, lb	176,010
Efficiency, %	72
Efficiency if added to ladle, %	90
Saving in efficiency, %	18
Saving in lb	31,700
Cost/lb, ¢	12.3
Saving/month, $	3,899.00
Saving/year, $	46,788.00
Saving/ton, $	1.95

This shows that there are great possibilities of decreasing costs if advantage is taken of metallurgical

knowledge and applying it to practices. For many years manganese has been added to the furnace. There is no just reason why this should continue in all cases. A little bit of thought should be given to the size heat, the type of manganese, its crushed size and to the method and equipment needed. If it is possible to add manganese to the ladle it should be done.

With the steady increase in material and labor costs taking place today, no company can afford not to take advantage of every opportunity to make steel more cheaply without sacrifice to quality. There is just as big a job breaking down old practical theories and practices as there is in developing new practices based upon sound research.

If asked to state the one greatest single cost in manufacturing open hearth steel, furnace life takes first place. Costs of rebuilds, idle man hours and loss of production are all heavy costs which bring back nothing in return. If we took stock of all the acid open hearths in the country it would be found that furnace lives varies from 400 to 1600 heats. This not only shows the possibilities of the process, but that the acid industry as a whole is not sufficiently cost conscious or cost intelligent.

The difference between 400 and 1600 heats in acid open hearth production is not much different than good basic operation (400 heats) and good acid operation (1600 heats). This is the approximate difference in cold metal stationary practice.

Certainly, all the above differences in furnace life are known. Why do some use acid and some basic? Why do some acid practices give life four times that of others? These questions can be easily answered since it is obvious that many plants are doing a poor job, probably from several standpoints.

RESEARCH CONTRIBUTIONS

There have been several valuable research contributions given to the foundry industry within the last several years, by the various foundry societies and by individuals. Whether you feel these research projects apply directly to you or not, or whether they are correct or incorrect does not detract from their value to the industry. There are many of these projects which apply to all which we either do not believe or have not taken time to apply them.

Every research project meets with heavy opposition and sometimes do seem to be incorrect. However, steel making is a big problem, and no research project covers more than a small part of that problem. The chances are that most research is correct, literally, but must be pieced together to make a good practice.

There are many problems both in the foundry and in the open hearth that have big influences and spell the difference between progress and good costs or poor practice and high costs. A few of the most important and influential problems are listed with the reasons why they are so important:

a) How should an acid open hearth be run to give longest life and the best quality? Do the conditions which produce a long life coincide with the conditions which produce the best quality?

b) Should an acid furnace heat be operated and refined to give a high and consistent efficiency on furnace additions? Does quality acid steel coincide with scientific viscosity and low slag oxidation control?

c) Can an acid open hearth be operated on a production basis, i.e., highly oxidizing furnace atmosphere, relatively low silicon and pig iron charge, large percentage of rusty and light scrap, highly active heats with fast carbon drops? Is this a positive or negative approach to quality? Is this conducive to long or short furnace life?

d) Scientifically, how should an acid heat be deoxidized? Does the sulfur content influence our decision? When we use complex or special deoxidizers are we substituting dollars for know how?

e) What is a hot tear? How much is progress slowed down by blaming this defect partially or wholly upon the open hearth without exerting whole-hearted effort on the foundry where it belongs?

f) How many companies can distinguish between porosity caused by under-deoxidation and that caused by improper gating and planning?

g) What is the importance of scientific heading, gating and chilling on the soundness and hot tearing?

Naturally, I believe the above questions are the most important and spell the difference between good and bad practice.

All the above questions have both scientific and practical proof. In the various plants at the author's company, each has been confronted, and the company believes that the right answer is a must. Being connected with research and steel making practice, it is the author's belief that acid steel has exceptional possibilities from both a quality and cost standpoint. In order to insure quality in acid steel we have to know the basic fundamentals of what we are trying to accomplish and run the furnaces accordingly. The practice that is fundamental for good quality is also fundamental for long furnace life.

In answer to the above questions, the author believes that all good acid steel making hinges around the ability to highly oxidize and retain all the oxygen possible in the finish product short of porosity. If this is true, there should be no half-way measures. If it requires an oxidizing condition, the furnace must be built and designed to be sharp. It must be operated to burn all the fuel possible as long as it is burnt before it reaches the last door. In other words, a furnace must be operated with adequate or excess air. It must be remembered that practically all the oxidation which takes place in an acid furnace must occur before the bath is melted and covered with slag. The oxidation of the slag continually decreases after the bath is covered with it.

If excess oxidation is needed, and all of it must take place before the bath is covered with slag, then everything that is done prior to that point is important. If a sharp oxidizing flame is necessary prior to meltdown in order to get enough oxidation, then it is just as important to think about the carbon

and silicon and the amount of rusty scrap to help out, or to insure enough oxidation or to avoid destroying it. If we have the correct type of furnace and operate it correctly, an acid heat can be charged with a good amount of rusty scrap, relatively low silicon and pig iron and still melt high enough in carbon. Such a heat will melt down with an active boil, get hot quick and drop fast.

Such a practice makes the finest acid heat possible even though at this point its control may be questionable. At this particular moment, it answers none of the requirements which have been in scientific papers or investigations. However, it does answer one of the fundamentals of making acid steel with a high sulfur content. The aim is to combat this sulfur with oxygen, the only possible way to do it.

DEOXIDATION

On such a heat, the slag will be black, the heat will be active and the carbon will be dropping fast. The efficiency of manganese, silicon, etc., added to such a heat would be poor, with losses from 40 to 50 per cent. Blocking with silicon alone would slow down the carbon drop but would not greatly improve the efficiency. Silicon, as a deoxidizer at higher temperatures, is so weak that its value is greatly lessened on such an oxidizing practice.

Even though high oxidation is the first step in making quality acid steel, it does not end with making a fast wild heat with poor control and poor alloy efficiency. Much more has to be done to control the practice and retain this quality.

The author's company has developed a control alloy which is designed to shape these heats up within a few minutes regardless of their activity without greatly deoxidizing them. This alloy contains 68 per cent iron, 26 per cent silicon and 6 per cent aluminum. The alloy is added in 1 to 2 in. size at 6 lb/ton to the bath as a block. The alloy is developed as an aluminum carrier of 0.36 lb of aluminum/ton of metal, which enters the slag.

This addition lowers the iron oxide in the slag sufficiently to stop transfer of iron oxide to the metal, thus stopping the boiling action. There is little or no deoxidation of the metal even though all activity stops. The alloy melts slowly, requiring 5 min to gradually stop activity. A bath deoxidized in this manner will remain dead indefinitely on an acid furnace, even though only a small amount of deoxidation has been done. After the aluminum/silicon-iron alloy has stopped activity, silicon and ferromanganese or silico-manganese is added for specification. Such a practice is an additional step in retaining high oxidation and gaining control of carbon. Such a practice, however, will not insure freedom from porosity unless further steps are taken. One of these precautions is temperature control.

Porosity Control

Research has shown that pouring temperature, silicon content and carbon content are all related to porosity control. For instance at 0.40 per cent silicon, 0.30 per cent carbon steel must be poured under 2850 F. As the carbon lowers 2850 F becomes more safe, and above 0.30 per cent carbon this temperature becomes less safe. Therefore temperatures are adjusted according to the carbon specification.

Naturally, making good acid steel becomes an involved problem, and there is no part of it that can be left unnoticed. We all recognize that in making all size heats a multitude of shapes and designs, etc., errors in temperature control are possible. The problems in retaining as much oxidation as possible, and at the same time avoiding porosity, becomes highly involved. To take chances on getting porosity or to overdeoxidize acid steel due to its sulfur content cannot be afforded.

One of the most useful of all research projects on deoxidation was done at the author's company. It was not basic research, but a study of literature on the thermodynamic behavior of carbon, silicon and aluminum done previously by several investigators. From this work were drawn curves and charts which showed its practical applications. From a knowledge of the behavior of these three elements we are able to use specific small amounts of aluminum to guard against porosity without lowering final deoxidation.

It is recognized that if the final oxygen level of steel up to a certain carbon content is controlled by silicon, good physical properties will result due to proper inclusion type. This is not safe against porosity, however, under all operating conditions. It is not safe enough at the instant the steel enters the mold, the time when porosity occurs. The temperature may or may not be cool enough for silicon to do its work under all conditions. It would only require a slightly lower oxygen to make the job safe. If only a small amount of aluminum is added, both the aluminum and a small amount of oxygen will be eliminated, after which the silicon will be strong enough after the temperature drops slightly.

DEOXIDATION PRACTICE

The author's company has devised a deoxidation practice which varies with the carbon content and somewhat is dependent upon the type of castings being poured (Table).

HOT TEARING AND POROSITY

It has been established that hot tearing is a physical defect and in no way related to the term steel quality. The susceptibility to hot tearing is entirely dependent upon the carbon content and its selective freezing phenomena. The incidence of hot tearing, that is, the amount of hot tearing we get, why its occurrence is so erratic, etc., is a more involved question.

Every grade of steel has a different selective freezing phenomenon. Even though the carbon content controls the lower temperature limit at which hot tearing can occur, the composition other than carbon greatly affects the temperature where the steel starts

DEOXIDATION PRACTICE

Grade Code	Carbon, %	lb/ton Aluminum in Fce, as Al-Si-Fe alloy	Ladle Aluminum	Total Aluminum
1	0.30 C min.	0.36	0.125	0.485
2	0.30-0.35 C.	0.36	0.125	0.485
3	0.32-0.38 C.	0.36	0.125	0.485
4	0.30-0.40 C.	0.36	0.125	0.485
5	0.30-0.40 C.	0.36	0.125	0.485
6	0.30 G max.	0.36	0.250	0.61
7	0.20-0.25 C.	0.36	0.250	0.61
8	0.25-0.30 C.	0.36	0.250	0.61
9	0.25-0.35 C.	0.36	0.250	0.61
10	0.25-0.35 C.	0.36	0.250	0.61
11	0.35-0.40 C.	0.36	2.50	2.85
12	0.40-0.45 C.	0.36	2.50	2.85
13	0.50-0.55 C.	0.36	2.50	2.85
14	0.65-0.75 C.	0.36	2.50	2.85
15	0.27-0.32 C.	0.60	None	0.60
16	0.30-0.40 C.	0.36	None	0.36
17	0.28-0.32 C.	None	None	None

NOTE: Steels 1 to 10 inclusive, are grades where it is possible to eliminate porosity with mild deoxidation and Type 1 inclusions.

Steels 11 to 14 inclusive, are grades which are impossible to deoxidize mildly and must be deoxidized to Type 3 inclusions.

Steel 15 is a high alloy steel.

Steel 16 is an alloy steel requiring room temperature izod impact tests.

Steel 17 is an alloy steel requiring sub-zero charpy impact tests.

to freeze. Some steels freeze over a wide range of temperature, while other compositions narrow this temperature range.

The actual cause of hot tearing is stresses acting upon a steel during its susceptible temperature range. All hot tears occur between the time they start to freeze and the lower hot tear temperature limit. On most foundry grades of steel, all hot tears occur above 2550 F. If all tearing is caused by one section of the casting pulling on another section, which is above 2550 F, then the solution to the problem lies chiefly in planning the chills, heads, and gates, to avoid this excessive temperature differential.

The only connection the open hearth or steel making furnaces has with hot tearing is the assistance it can offer in supplying consistent pouring temperatures. It is almost impossible to plan intelligently unless consistent pouring temperatures are supplied to the foundry.

Much has been written in recent years about the subject of hot tearing and we will not go into the subject here. However, it is important to mention the fact that much progress on scientific heading and gating has been deterred by placing the blame for hot tearing on the steel making process.

POROSITY SOURCES

Porosity is an important problem in the manufacture of steel castings. It is important because porosity can originate from several sources. Unless they are understood the tendency naturally is to over-deoxidize or spend a lot of money for special deoxidizers. In the plants of the author's company where a large variety of compositions and casting sizes and designs are made, porosity comes from two sources.

The main source is furnace deoxidation due to the fact that the approach used calls for mild deoxidations and relatively low pouring temperature. The second source of porosity danger lies in the association of a relatively low temperature pouring practice with certain casting designs. Much care must be taken to avoid filming or partial freezing of the surface of the metal on certain thin sections while the castings are being poured. On many large intricate castings either they must be gated to produce more turbulance or poured at a higher rate and temperature to avoid filming or partial freezing on certain sections while the casting is filling. The surface of the metal will oxidize severely if it films or partially freezes, and when folded under, will boil and cause porosity.

In the author's company's plant all porous conditions are carefully analyzed to first determine their cause before any steps are taken. Furnace deoxidation is the chief cause of porosity in the company, however, in certain cases the planning has to be checked.

LINING-LESS WATER-COOLED CUPOLA OPERATING EXPERIENCE

by M. E. Rollman and D. J. Pusack

ABSTRACT

The authors present a description of a lining-less water cooled hot blast cupola being used for production of high strength gray iron machine component castings. Furnace construction, refractory practice, water cooling system, hot blast system and operating techniques are described. Stress is laid on the principle that gains in casting quality through improved control are more significant than the well recognized cost reductions possible with this type of melting unit.

INTRODUCTION

Previous publications of the American Foundrymen's Society have described to cupola furnace operators, the metallurgical theory and the experimental installations that have gone into development of the externally-cooled lining-less, controlled slag, hot blast cupola.[1] This paper intends to portray from the foundryman's viewpoint a production installation of this type furnace that has been successfully operating at the author's company since Oct. 1958.

Data are presented to illustrate the principle that these furnaces can be used economically to produce high strength gray iron within close composition limits, while achieving a higher degree of cleanliness and castability than has been obtained with conventional acid or basic cupola melting units.

Objectives of the installation were manifold. First and paramount was the need to develop a melting practice that enables a close control over variations in metal analysis, i.e., carbon and silicon. Conventional basic melting as practiced in the foundry resulted in wide variations in carbon that often were found undesirable when producing class 30 and class 40 inoculated gray irons for machine tool components.

The company desired to combine the advantages of basic melting, such as usage of low cost raw materials, production of hot, unoxidized metal and reduction of metal wastage resulting from down time and inferior starting conditions, with a means to more closely control the chemistry and thereby the mechanical properties of the metal.

Other advantages to be realized that were rated as significant but less important were:

1) Reduction in cost through negligible refractory consumption.
2) Reduction of cupola maintenance labor cost.
3) Reduction in fuel cost through coke savings.
4) Reduction in cost of silicon and manganese through decreased melting loss of these components.
5) Improvement in flexibility of foundry pouring schedules by utilizing one grade of closely controlled base metal, modified by ladle alloy additions, to make castings ranging in weight from a few ounces to 40,000 lbs and in section from 1/4 to 6 in.

FURNACE DESCRIPTION

The furnace melting section is a one in. thick mild steel shell 13½-ft high rolled into a modified cone as illustrated (Fig. 1). Diameters of the various zones are 70 in. in the well, 54 in. at the top of the combustion zone and 50 in. at the top of the preheat zone where the cone is flanged to the charging section. Ports are

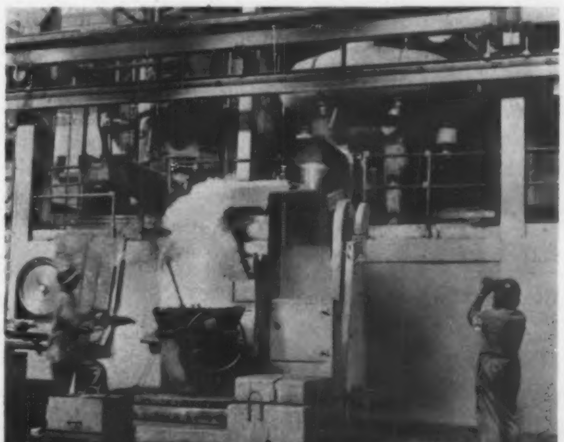


Fig. 1 — General view of furnace installation.

M. E. ROLLMAN is Fdy. Supt., and D. J. PUSAK is Fdy. Met., The Cincinnati Milling Machine Co., Cincinnati, Ohio.

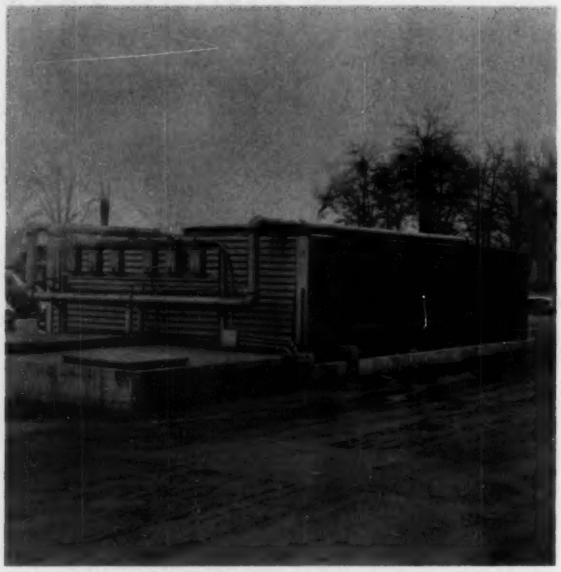


Fig. 2 — Cooling tower for recirculating cooling water. Capacity of tower was planned for two cupolas operating simultaneously.

provided through the shell for the placement of six flange-connected, fabricated copper water-cooled tuyeres. The tuyeres have an external diameter of 8 in. and internal diameter of 5 in.

Projection of the tuyere body into the cupola is 12 in. They are inclined downwards from the horizontal by 15 degrees. Within the tuyere, the cooling water is conducted to and away from the nose by 5/8-in. diameter tubing to prevent vapor locks.

The shell of the cupola is externally cooled by a curtain of water flowing down the cone from the 13½-ft height into a gutter immediately below the tuyeres. Two 180 degree water pipe segments are used to jet the water against the shell. The film is maintained by a shield below the spray ring with a 1/16-in. gap. Supplemental spray ring cooling is employed in the well section from the upper gutter down to the cupola base.

The 13½-ft melting section is flanged with an expansion joint to the original 66 in. diameter charging door section and stack. The expansion joint is packed with asbestos rope, and protected internally by an overhanging nose on the lowest row of heat resistant cast iron charging block. Erection of the melting section was effected by adding structural support to the original stack below charging door level, cutting away the original melting section and base plate, inserting the new melting section and base plate and flanging to the old stack as described.

REFRACTORY CONSTRUCTION

A carbon block lining is installed in the well section of the furnace. Two courses of chrome-magnesite 2½-in. key brick sit upon the bottom plate which has an opening of 48 in. diameter. These form the base for nine large carbon well blocks and one carbon breast block, which stand 24 in. high immediately in front of one row of 9 in. carbon arches placed next to the shell. The breast block has a nose which projects through the breast opening of the shell 5½-in. A milled slot in the breast block receives key bricks 21 in. long which form the taphole, and are replaceable at weekly intervals. The lower key is magnesite and the upper is carbon.

The original design provided for an additional course of smaller carbon blocks to set above the large blocks and between the six tuyeres. Carbon paste was used to ram immediately adjacent to the tuyere bodies. Operating experience has demonstrated that these blocks and paste are not durable in contact with the oxygen of the preheated blast. Therefore a contour patch of gun emplaced dolomitic refractory is filled in at tuyere level and carried up the side wall ½-in. thick for 2 ft. No refractories are used in the upper combustion zone or preheat zone.

Repair is performed once a week on the carbon block during the weekend shutdown, using carbon paste patching to maintain an internal well diameter of 54 in. During repair, the heated and softened paste is bonded to the parent blocks with a coating of 150 F pitch tar cement. Air ramming is used to achieve a dense structure. After gunning the dolomite refractory above the carbon paste patch, the doors are closed and a molding sand bottom is rammed to a depth of 12 in.

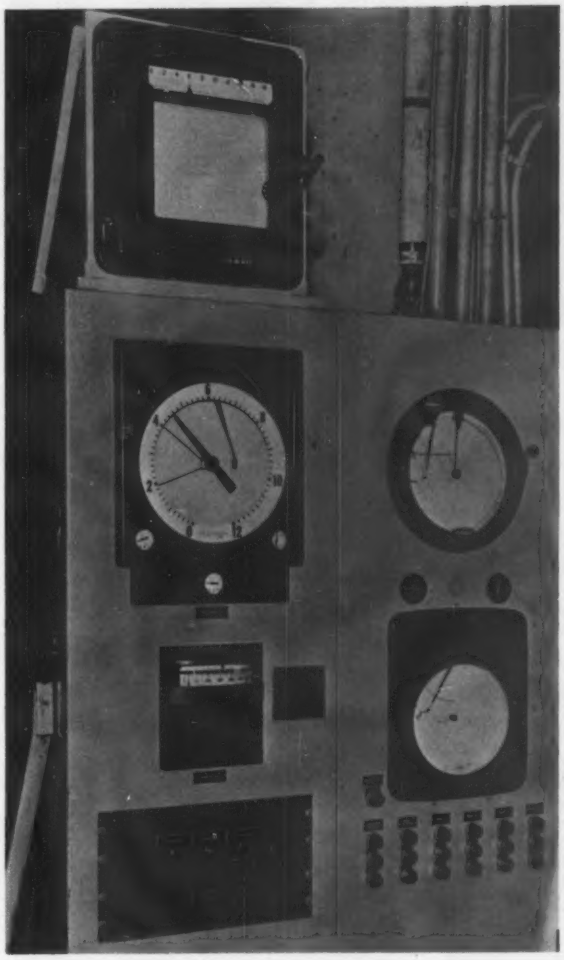
The top of the sand is covered with a 2 in. layer of high alumina ramming mix to retard bottom erosion and prevent early formation of an iron and slag skull in the well. This particular practice has improved initial metal temperature and fluidity on start up after night time banking. Hot coke, burning with natural draft, is charged into the cupola immediately after repair, to dry and glaze the refractory patch and provide a base for rapid bed preparation on Monday morning.

The front slagging cupola spout is lined with a composite structure of carbon and basic bricks. Chrome-magnesite straights are used up to the slag metal interface and carbon bricks above this to the edge of the slag spout. Dam bricks and runway bricks beyond the dam are chrome-magnesite. During operation, the slag pool is covered with a heavy layer of charcoal and vermiculite to insulate the molten slag and protect the carbon brick from oxidation. Further attention to the spout is unnecessary during the day's melting. Some patching of the breast face and cupola runway is required each morning prior to tapout.

COOLING WATER SYSTEM

Cooling water for the cupola is continuously recirculated at a rate of 220 gpm. The heated water from the cupola is pumped through an induced draft evaporative cooling tower at the rate of 350 gpm (Fig. 2). After cooling, 130 gpm is used as continuous dilution of the hot 220 gpm flowing by gravity from the cupola. Effluent temperatures of 140 F can be reduced under summertime conditions to 90 F. Evaporative losses are approximately 5 per cent. An automatically operating safety valve is installed on an alternate water supply to provide instantaneous flow in the event of pump or power failure.

Fig. 3 — Furnace control panel showing 1) stack gas temperature recorder, 2) air blast preheat control, 3) high limit scanner, 4) air weight controller, 5) bustle pipe pressure recorder and 6) blower and burner starting switches.



HOT BLAST SYSTEM

Several years melting experience with the cold blast water-jacketed cupolas provided convincing, although negative evidence, that a preheated air blast would be necessary for successful water cooled lining-less operation. Characteristic of any cold blast operation is a spread-out combustion zone with a relatively high zone of free oxygen above the tuyeres, followed by another high zone of CO-CO_2 gas mixture where melting occurs. Observation of refractory burnout in a conventional cupola customarily reveals this high temperature zone existing to a height of 42-48 in. above the tuyeres.

Substitution of water cooling for refractory provides the opportunity for high rates of heat extraction along the side walls, with consequent vertical enlargement of the zone of free oxygen and distinct reduction in the degree of superheat attainable in the metal.

The principal advantage that is obtained from the use of a preheated blast is to compress and restrict the vertical height of the combustion zone. This minimizes the height of the free oxygen zone existing above the tuyeres with consequent cleaner, hotter melting. It also reduces the loss of heat units to the cooling medium at the point where they are most needed to produce a satisfactory degree of metal superheat. Observation of metal shell temperatures during melting indicates an intensely hot combustion zone to a height of only 18 in. above the tuyeres.

An additional advantage is that the requirement for coke fuel is reduced by virtue of the sensible heat of the entering air blast.

The hot blast installation on the new cupola (Fig. 3) is used as a melting control tool to attain the objective of hot, clean, fast melting. At the same time, manipulation of the temperature output of the hot blast burners provides a means to continuously correct variations in melting conditions. Laboratory results at 20-30 min intervals on carbon content are the basis for alterations of blast temperature to maintain the desired mean level of individual carbons within a 20 point range.

Fundamental considerations in cupola practice such as coke percentage, slag basicity, air volume, choice of raw materials, etc., are still vital to establish the mean carbon content at the desired level while achieving the necessary degree of metal fluidity and cleanliness. Alterations in blast temperature during the progress of a particular heat are kept within fairly well established limits of $\pm$ 100 F to over-ride the unpredictable melting variations with which every cupola operator is familiar. Wide alterations in blast temperature will produce adverse effects on metal fluidity and degree of oxidation that should be avoided.

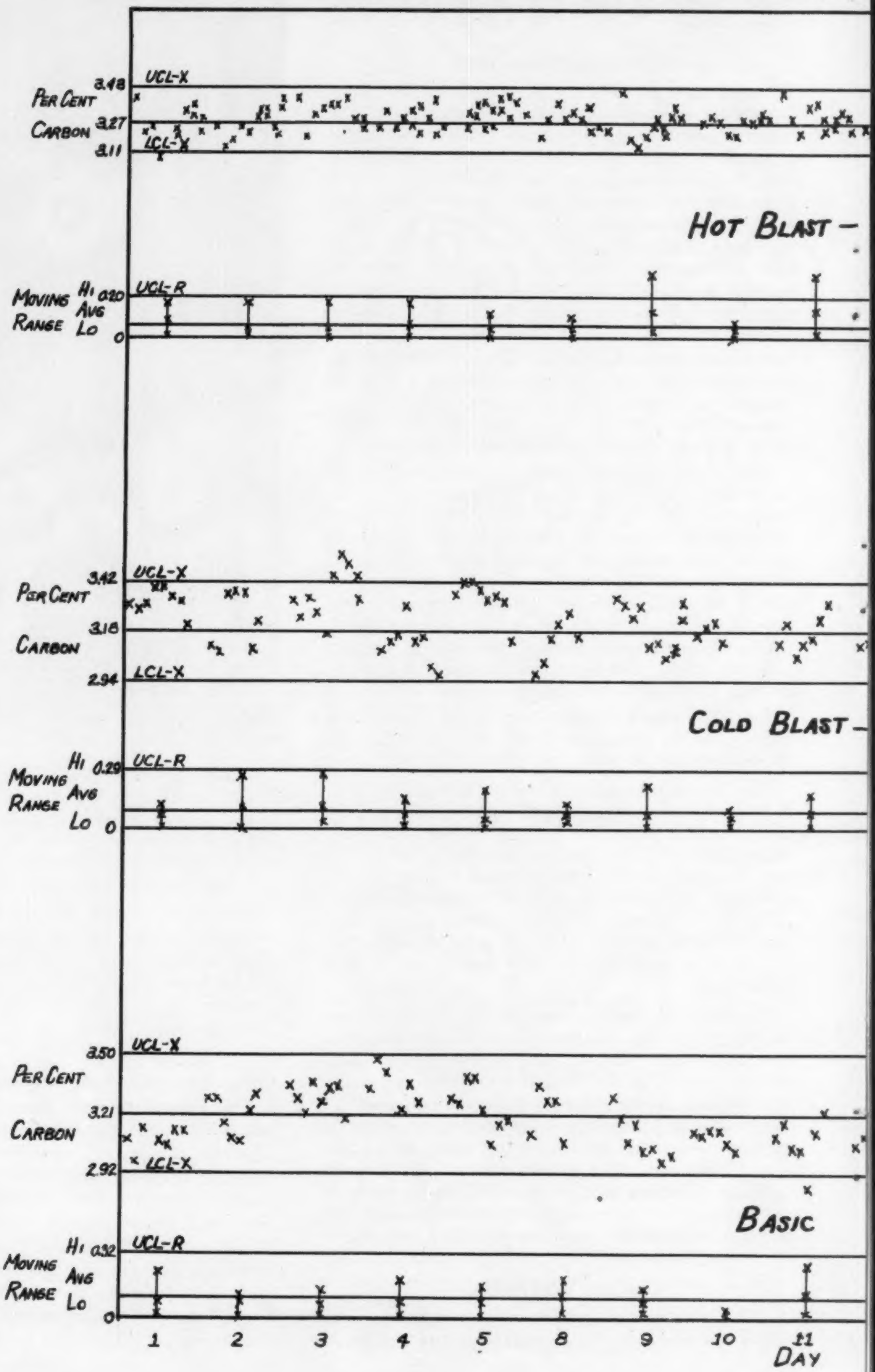
SLAG CONTROL

After establishing a given make up of charge, coke volume, average air blast temperature and volume in the lining-less cupola, the most useful tool to bring about a fundamental change of mean carbon content is slag control. It is unfortunate that no convenient, rapid yet precise method for slag analysis, i.e., basicity ratio, is available to the operating metallurgist. However slag fractures and color charts provide a crude method of estimating results on a continuous basis.

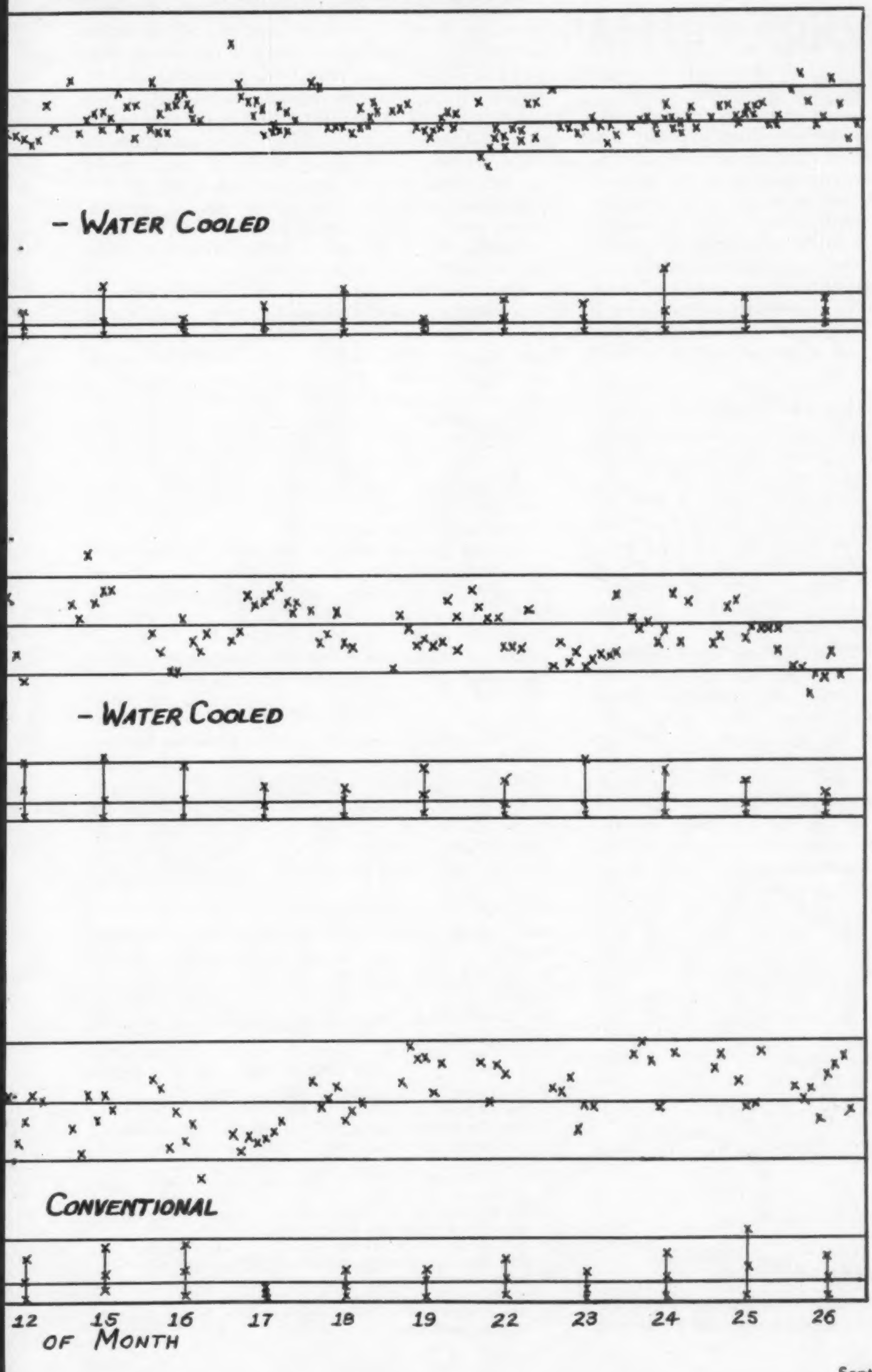
Changes in mixtures of fluxing materials such as limestone, fluorspar, return slag and silica pebbles can be made during the heat as desired to produce carbon contents of 3.00 per cent to over 4.00 per cent from the same mix with varying degrees of silicon loss and sulfur removal.

The externally fired hot blast equipment is the vertical finned-tube type. Three 29 ft units in parallel, installed between the cupola operating deck and the roof line, can preheat 4000 cfm of air to 900 F and 5000 cfm to 700 F using natural gas or oil for fuel. Heated air from the three units is mixed in a bustle pipe and delivered through stainless steel downcomers to the six tuyeres. Flame control is accomplished through a thermocouple and controller system acting upon a modulating valve to continuously vary each burner's output from 800,000 Btu/hr to 1,800,000 Btu/hr.

FIG. 4 - SQC CHART FOR INDIVIDUAL



CARBONS — MONTH OF SEPTEMBER



Thermocouple signals from each tube are scanned by one high limit control at 20 sec intervals to prevent overheating of individual units. A bypass stack to atmosphere allows for short shutdowns in melting without losing air blast temperature control. The burner controls are interlocked with the cupola blower to provide for shutoff in event of air blast failure.

Our choice of this type of externally fired preheating equipment has provided operating simplicity and flexibility. There are no cleaning problems or thermal lag at startup as usually encountered on the recuperative type. Floor space requirements are an absolute minimum due to the vertical installation. Operating economies have proved to be substantial even after offsetting coke savings with natural gas cost. Coke consumption has decreased 15 per cent compared with the former basic practice, while still achieving high metal temperatures. Gas cost has partially offset this saving so a net reduction of 12 per cent in melting fuel costs is realized.

OPERATING FEATURES

The new cupola is operated 8 to 9 melting hr/day for 5 consecutive days each week. Draining and banking of the furnace is done after each day's melt. Repair of well, breast and front slagging trough is done on Saturday. Each morning including Monday a residue of ignited coke is available in the well to initiate combustion during bed preparation. The coke bed is burned in to a height of 40-45 in. using thermocouple measurement of the gas temperature at the charging door to reproduce initial conditions closely.

During meltdown the blast temperature is adjusted to 500 F at a volume of 5000 cfm. This high air volume with a high initial bed assists in achieving hot fluid melting at tap out time. The tap hole is opened with an oxygen lance when the well is full. Adjustments in blast temperature and blast volume are made as the early period of control and fluidity difficulty passes. Normal valves are 4600 cfm at 500-600 F.

Data are presented in Figure 4 illustrating the degree of control of total carbon achieved in the new furnace, presented on a statistical quality control chart. Comparative data for other types of melting in previous years are presented also. Results were selected on the same class of high strength inoculated iron during the similar season of the year to rule out variations due to atmospheric conditions.

The data presented are based on the statistical theory of a moving range for individual carbons. The following definitions apply:

Mean Carbon...... $\overline{X} = \dfrac{\Sigma X}{n}$

Mean Range ...... $\overline{R} = \dfrac{\Sigma (X_1 - X_2) + (X_2 - X_3) + \cdots (X_{n-1} - X_n)}{n}$

Upper Control Limit........ $UCL = \overline{X} + 2.66\,\overline{R}$

Lower Control Limit........ $LCL = \overline{X} - 2.66\,\overline{R}$

Control limits are defined as statistical limits for normal populations of data, and are not to be considered as specification limits. They include 99.7 per cent of the variables.

The new process achieves a mean range between successive samples of 0.06 per cent and a population spread (UCL minus LCL) of just 0.32 per cent as compared to $\overline{R}$ of 0.11 per cent, UCL minus LCL of 0.58 per cent in the conventional basic melting, $\overline{R}$ of 0.09 per cent and UCL minus LCL of 0.48 per cent in the cold blast water cooled melting. These reductions in value are statistically significant on a control chart for individual carbons, and represent a distinct improvement in the control of the melting process. Stated another way, it can be expected with statistical confidence that 95 per cent of individual carbon values will fall within a 20 point range.

With this close control of carbon content at hand it is possible to melt a single base iron, modify with suitable ladle additions of ferrosilicon and inoculate with alkaline earth silicides, to pour castings of widely varying section size. This feature allows an important gain in flexibility of assembly and pouring schedules, and simplifies cupola charging procedure. A single mix weighing 2000 lb containing coke and flux with briquetted steel turnings, briquetted cast iron borings, silvery pig iron, malleable pig iron, domestic returns and ferro alloys is used. Charging is done with cone bottom skips by monorail hoist.

Melting rates of 10 to 11 tons/hr are realized with the new furnace. This provides additional productive capacity at peak periods with no lengthening working hours. Refractory materials cost has been reduced drastically, being 5 per cent of previous conventional practice. Ten man-hr labor are expended to prepare the inside of the cupola for a full week's run.

CONCLUSION

At the authors' company is a cupola melting furnace which produces iron to quality levels and economical cost standards which once was thought of as unattainable by practicing foundrymen. In this particular installation, careful engineering and planning incorporated the components of the new melting plant into existing facilities with negligible disruption or building alteration.

Review of the literature reveals that many of the early installations of this type water-cooled hot-blast cupolas were intended for specialized applications and specialized casting products. However, improvement in casting quality along with the inherent economies of the process make it useful for production of all types of engineering irons.

REFERENCES

1. D. Fleming, "The Controlled Slag Hot Blast Cupola," AFS Transactions, *vol. 66*, p. 113 (1958).
2. Ernst Loebbecke, "Development of Hot Blast Cupola Melting Technique in Europe," AFS Transactions, *vol. 64*, p. 171 (1956).
3. W. L. Heinrichs, "Hot Blast Cupola Practice," AFS Transactions, *vol. 64*, p. 532 (1956).
4. W. R. Jaeschke, "Development of Cupola Melting Equipment," AFS Transactions, *vol. 62*, p. 339 (1954).
5. T. J. Wilde, M. R. Hatfield, and V. J. Nolan, "Carbon as a Refractory," AFS Transactions, *vol. 61*, p. 640 (1953).
6. Wally Levi, "Melting Iron in a Basic Lined Water Cooled Cupola," AFS Transactions, *vol. 60*, p. 740 (1952).
7. The Cupola and its Operation, American Foundrymen's Society, p. 166 (1954).

ELECTROFORMING FOR PATTERN CONSTRUCTION AND REPAIR

by P. Ritzenthaler

ABSTRACT

The process of electroforming is described by the author. Various applications are outlined — as salvage plating of worn or undersized patterns, cladding of aluminum patterns and electroforming for the manufacture of patterns for sand, precision casting and shell molding.

INTRODUCTION

Electroforming is not a newcomer in the pattern field, as it has been known and used, if to a limited extent, for nearly 50 years.

Electroforming is the production of an electroplated deposit heavy enough to have its own set of properties independent of a base metal. In other words, the deposit itself becomes a useable article such as a pattern.

Most people think of electroplating as a relatively thin deposit applied to another metal to make it rust resistant, to enhance its appearance, to increase its conductivity or its wear resistance. Few people outside the trade have ever seen an electrodeposit heavy enough to stand by itself.

An electroformed shell can be anywhere from 0.005 in. to ½-in. thick, (500 thousandths) requiring from 5 hr to 4 weeks of plating.

Another name for electroforming is cold casting, since it is about the only way a metal can be "cast" at temperatures only slightly above room temperatures, such as 100 - 145 F, which eliminates many distortion problems due to heat.

Thus, in electroforming the plater must turn metallurgist, for he then becomes concerned with the physical properties of the deposited metal such as hardness, durability, tensile strength and internal stress.

PHYSICAL PROPERTIES

For example the physical properties of the three most commonly electroformed metals are:

P. RITZENTHALER is with Plating Engrg. Co., West Allis, Wis.

	Brinell Hardness	T.S., psi	Elongation, %
1. Copper	80-270	20,000- 50,000	35-15
2 Nickel	120-550	50,000-200,000	30- 5
3. Iron	100-350	40,000- 90,000	30-10

Internal Stress is also an important factor, as is the wear resistance of the coating used.

The choice of metal to be used depends on the type of service. Copper is the softest of the three, and nickel the best for hardness and wear, as well as for resistance to chemical attack by the resins and other chemicals used.

PLASTIC PATTERNS

A great deal of work has been done to introduce and use plastic patterns in the foundry, mainly the epoxy resins. These types of patterns have revolutionized pattern shop practice. However, they are still not as good as metals in a number of respects:

1) They are not as hard, and hence will not wear as well as metal.
2) They are more brittle and will chip or flake off under impact or pressure.

They also will not stand heat as well as most metals, and lose strength when hot. They will disintegrate at shell molding temperatures of 600 F. They also have relatively poor heat transfer, hence cannot be used for shell molds, etc. There are many places, especially on high production jobs, where plastics just are not good enough.

We are concerned in this paper with three main fields of interest to patternmakers:

1) Nickel salvage plating to build up worn or undersized patterns.
2) Nickel cladding of aluminum patterns to increase wear.
3) The manufacture of patterns by the electroplating of metal shells.

SALVAGE PLATING OF WORN OR UNDERSIZED PATTERNS

Electroplating is the excellent putting on tool that everyone has been looking for. It is a way of putting

metal on to a metal pattern that is worn or is undersized through a machining error. It can also be used to add metal required by an engineering change to a heavier section, etc.

The best metal to use here is nickel for cast iron, steel, aluminum or brass patterns, although copper plating is sometimes used on brass or aluminum patterns where high wear is not required.

The advantages of plating are the lack of warpage that welding might give you, plus readily machinable deposits of nearly any desired thickness from 0.002 to $\frac{1}{8}$-in.

The wear on nickel plating is excellent. One high production job reported no visible wear at 100,000 cycles. The plating can be applied to only the section desired, the rest of the part being protected with wax or stop-off lacquer so it will not plate.

CLADDING OF ALUMINUM PATTERNS

The aluminum patterns are plated with 0.005 to 0.015 in. semi-hard nickel to increase the wear resistance over the relatively soft aluminum. Nickel coating will increase the wear from 5-10 times over unplated aluminum, according to users.

Another advantage of this type of coating is the restoration of original sharp contours on worn patterns by plating. Since plating tends to build up faster on the high spots, and since these are the places where wear is the greatest, the plating tends to build up the worn areas faster and hence restores the original contour.

Nickel plating can also be used instead of pinning on steel wear plates on faces of patterns. It is cheaper, and less time consuming to do this by plating.

ELECTROFORMING FOR MANUFACTURE OF PATTERNS

While the previous two fields for electroforming are important, it is felt that in the field of actual pattern construction that the greatest potential exists. Again, there are several types of patterns that can be made.

Sand Patterns

These consist of copper or nickel shells backed with babbitt or plastic to make a flat block. Thus, we have made a metal-faced pattern to give us high wear, and have made it into a block in a rather simple manner.

This gives a pattern that will not wear or chip like epoxy resin, and one that will outwear aluminum. This process is at a cost competitive with other processes and with a much better surface finish, free from the pits and porosity often experienced in cast aluminum.

These patterns are highly accurate. After all, Phonograph record molds are all made by electroforming, and if you can reproduce the sound track of a record, that is the ultimate in detail. Also, in this process there is no shrinkage, so no extra shrink allowance need be furnished such as in casting aluminum patterns.

One of the chief problems on Shaw cast patterns is the high and inconsistent shrink on large parts. On parts 16 in. and over with the Shaw process, about 0.040 in. must be allowed. In plating, no change in size occurs.

The shell is made by plating against any epoxy or other suitable plastic negative mold, made from a wood or metal master. When this epoxy negative mold is plated the plating gives a positive impression, the same as the original master.

This process is well adapted to the making of the multiple patterns, all of which will be an exact duplicate of the master.

Molds for Making Wax Patterns for Precision Casting

These are two piece molds, as opposed to single patterns used in sand molding.

The pattern is set up on a block of wax at the parting line and the first half plated. The wax is melted off, and the second half is plated against the first half so accurate registration is possible even along an irregular parting line. These shells are then backed up with babbitt to make a block to make an operating mold.

A metal electroformed mold makes highly accurate wax patterns, with a surface finish not possible with other processes. The mold surface is nonporous, and can be highly polished if desired so that the waxes will release easily.

Shell Molding Patterns

This is a relatively new field, but one that is certain to grow as nickel electroformed shells are ideal for shell molding due to their high strength and resistance to heat. Nickel melts at 2600 F.

The electroformed nickel shells are made into a box by fastening steel strips around the outside to make a frame, and backed with metal or other conductive material. Although the actual manufacture of the electroformed patterns is done by the electroforming shop, a few of the highlights of the process will be given for general information.

First, the pattern must be furnished by the customer. The original pattern can be metal, plaster or wood, but these are not plated. From the master pattern a negative mold must be made of epoxy to plate against. The author believes this should be done by the patterns shop, as they are set up to do it and are familiar with the technique.

Plaster and wood cannot be successfully plated, as the wood warps and the plaster is attacked by the acid in the plating bath. The epoxy negative which is to be plated is set up for plating by bolting contact hooks to it.

It is then made conductive by spraying with silver. It is placed in the proper plating bath and plated to the desired thickness. This may be anywhere from 0.030 to $\frac{1}{4}$-in. depending on the shell desired.

The plating solution will faithfully reproduce the surface of the mold, even down to the finest scratches. The pattern will be an exact copy of the original pattern.

While the field for electroformed patterns has only recently been actively exploited, it is felt they can fill an important place in the pattern industry, as a way of making stronger and more accurate patterns.

PREMIUM QUALITY MAGNESIUM CASTINGS FOR MISSILE APPLICATIONS

Techniques for producing

by M. C. Flemings, E. J. Poirier and H. F. Taylor

ABSTRACT

A summary is given of techniques employed in the M.I.T. foundry laboratory for producing prototype magnesium castings for missile applications. Research presented deals primarily with AZ91C alloy (8.7% Al, 0.7% Zn, 0.15% Mn, bal Mg). Foundry techniques including melting, molding, gating and risering, chilling, etc., are discussed in detail. Research on mold coatings to improve fluidity is presented. Mold coatings found to be effective were amorphous carbon and hexachloroethane; amorphous carbon improved fluidity by as much as 100 per cent. Fluidity of a series of magnesium alloys was found to decrease in the order 1) pure magnesium, 2) AZ92A, 3) AZ91C and 4) ZK51A and KIA.

Application of careful foundry techniques to production of several prototype castings is described. The castings are 1) a simple hemispherical gimbal, 2) a large thin section casting requiring close control of dimensions (±1/64-in. in some locations) and 3) a gimbal casting requiring integrally cast tubes for heat exchange purposes.

INTRODUCTION

Since 1954 a research program has been sponsored in the M.I.T. foundry laboratory by the Air Force through the M.I.T. Instrumentation Laboratory, to 1) conduct basic research in the area of light metal castings and 2) translate basic research results into practical techniques for producing high quality prototype castings for missile applications. Research in the early phases of this program was conducted primarily on aluminum alloys.

Later, magnesium alloys were emphasized to a greater extent, largely because magnesium has inherent advantages (for example, high stiffness-to-weight ratio) for certain missile applications. Two reports have been issued outlining the more practical aspects of this work, the first on aluminum[1] and the second on magnesium.[2]

This paper is largely abstracted from the second report above, and describes work conducted on magnesium castings to increase and extend properties, serviceability and design latitude of castings for missile applications. Research reported deals almost exclusively with AZ91C alloy (8.7% Al, 0.7% Zn, 0.15% Mn, bal Mg).

Specifically, the paper comprises 1) foundry techniques employed to produce high quality castings, 2) a study conducted to increase the fluidity of magnesium alloys and 3) representative prototype castings showing application of techniques for producing magnesium castings with high mechanical properties, thin sections, close dimensional control and with small diameter cored passageways. Detailed descriptions of experimental techniques are omitted; these may be found in the report on which this paper is based,[2] or in previously published technical articles.[3-6]

M. C. FLEMINGS is Asst. Prof. of Met., E. J. POIRIER is Graduate Student, formerly Research Staff Member and H. F. TAYLOR is Prof. of Met., Massachusetts Institute of Technology, Cambridge.

FOUNDRY TECHNIQUES

Certain practices described herein are those recommended in the technical literature, particularly in various publications of Dow Chemical Co.;[7,8] others were developed at M.I.T. in the course of this work. Techniques apply primarily to AZ91C alloy, but many apply equally well to other magnesium alloys (particularly to other alloys of the magnesium-aluminum-zinc family).

Chemical Control and Melting Practice

Table 1 lists nominal analysis and permissible compositional range for AZ91C alloy. Melt charges were made from high purity virgin materials or from al-

TABLE 1 — CHEMICAL REQUIREMENTS OF MAGNESIUM ALLOY AZ91C

Elements	Nominal	Range (QQ-M-56a)
Al	8.7	8.1 -9.3
Zn	0.7	0.40-1.0
Mn (min)	0.18	0.15
Cu (max)		0.10
Ni (max)		0.10
Si (max)		0.30
Others (max)		0.30

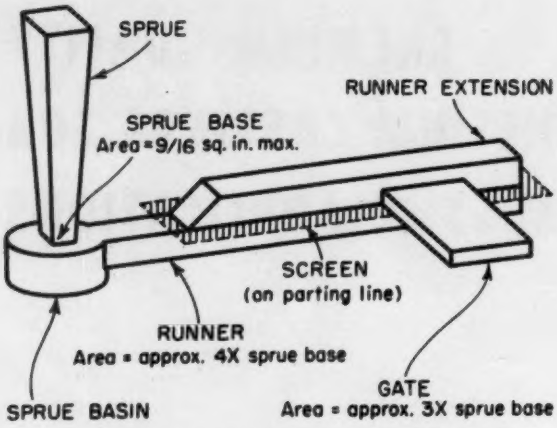


Fig. 1 — Gating system developed in M.I.T. foundry laboratory for magnesium alloy castings.

loyed ingots previously produced from high purity materials (virgin or foundry returns); alloyed ingots comprised 75 per cent of the heat. Virgin materials were magnesium (99.8%), aluminum (99.99%), zinc (99.9%) and aluminum-manganese master alloy (25% Mn).

Melting was done in iron pots using a gas fired furnace. All tools in contact with the metal were of iron or graphite. After meltdown and addition of charges, the metal was degassed with chlorine at 1330 to 1380 F, and grain refined by the superheat method (heated to 1650 F and held 15-20 min). Proprietary fluxes were used throughout melting and pouring to prevent burning. Table 2 lists in detail the steps followed in melting AZ91C.

Sand Practice

Most of the castings produced in this program were made in green sand of AFS 80 fineness. Cores were bonded with urea-formaldehyde or sodium silicate

TABLE 2 — FOUNDRY LABORATORY STANDARD MELTING PRACTICE

Gas furnace melting of magnesium-aluminum-zinc alloys.

1. Calculate charge.
2. Preheat iron crucible, tools, ladles, pigs, charge additions and flux immediately before use.
3. Cover the bottom of the crucible with a thin layer of flux. Charge pig (charge alloyed pig before pure magnesium). Add aluminum and manganese master alloys at the beginning of meltdown, after a heel is formed.
4. Dust flux into casting crucible at frequent intervals during melting to prevent burning.
5. At 1250 F add zinc alloy.
6. Heat to 1300 F, stir bath one min with a gentle circular motion from bottom to top of crucible; avoid breaking surface of the melt.
7. At 1330 F, degas with chlorine for 10 min. Place graphite degassing tube 5 - 8 in. from bottom of crucible; bubble at a sufficient rate to obtain a rolling motion on the melt surface. Hold degas temperature between 1330 F and 1380 F.
8. Heat to 1650 F, hold 15 min.
9. Remove crucible from furnace. Cool to 25 F above tap temperature. Skim. Remove loose flux from pot walls and crucible lip with a scraper and wire brush. Sprinkle agent over melt to prevent burning.
10. Pour. Dust flux over sprue entrance before pour, and over metal stream during pour.

TABLE 3 — SAND MIXES

Ingredients	Weight, %
Molding Sand	
No. 80 Sand	88.0
Southern bentonite	4.5
Sulfur	1.5
Boric acid	1.5
Diethylene glycol	1.5
Water	3.0
Urea-formaldehyde Core Sand	
No. 80 Sand	70.0
No. 140 Sand	21.25
Cereal	0.75
Boric acid	1.5
Sulfur	1.5
Urea-formaldehyde	1.0
Water	4.0
Sodium Silicate Core Sand	
No. 80 Sand	70.0
No. 140 Sand	22.0
Sulfur*	3.0
Proprietary sodium silicate binder	5.0

*Potassium fluoborate may be used in place of sulfur.

$-CO_2$. Inhibitors were sulfur and boric acid for green clay-bonded sand and the urea bonded sand, and sulfur alone for the sand bonded with sodium silicate. For one casting (Fig. 17), the mold was preheated for an extended period before pouring. In this case potassium fluoborate was used as the inhibitor. Where danger of "burning" was present, as for example at gate entrances or on drag surfaces, finished molds were sprayed with a solution of ammonium fluoborate in alcohol. Table 3 lists the various sand mixes employed.

Gating

The gating system developed in the course of this work, and used throughout most of the program, is illustrated in Fig. 1. It is an adaptation of a system described earlier for making aluminum castings,[1,5] designed to provide a smooth even flow of metal to the casting cavity with a screen to filter any foreign inclusions. Essential features are 1) tapered sprue, 2) sprue basin, 3) drag-to-cope runner, 4) cope gates, 5) unpressurized gating ratio ("choke" at the base of the sprue), 6) screen at the parting line and 7) runner extension.

Runner shape is determined so that screen area is always at least 80 times the area of the sprue base (to eliminate danger of clogging the screen). Additional details on design and use of this system have been given earlier.[2]

Heat Treatment

All mechanical properties reported herein are for castings in the T6 condition (solution treated and aged). The following heat treating schedule was used throughout for AZ91C alloy:

Solution treatment:
2 hr at 665 F.
6 hr at 775 F.
2 hr at 665 F.
10 hr at 775 F.
air cool to room temperature.

Aging treatment:
16 hr at 335 F.

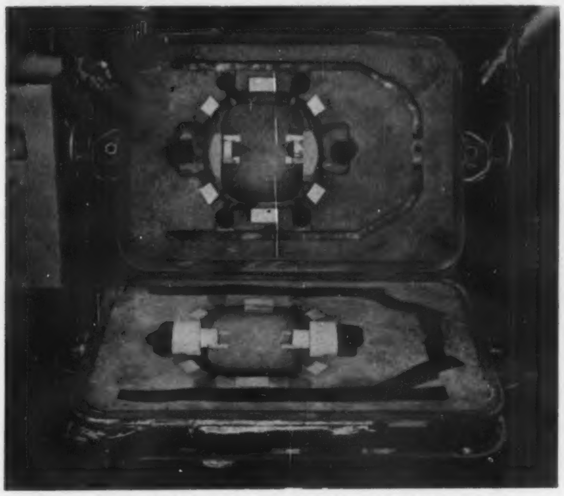


Fig. 2 — Mold for producing high strength large magnesium gimbal.

Risering and Chilling

In general, risers for magnesium alloy castings must be large and closely spaced. Side risers, expecially side risers which are attached directly to gates, are desirable. These risers must not be placed too close to the casting, or the heat effect of the riser will create, rather than eliminate, shrinkage in the area of the casting near the riser. A useful rule of thumb is that the riser should be spaced a distance from the casting at least equal to ⅔ the diameter of the riser. The riser is then joined to the casting by a section (a "riser pad") not thicker than ⅔ the diameter of the riser. Figure 9 shows one example of side risers, with attached riser pads.

Chills are frequently employed to promote directional solidification in complex castings and to achieve a fine, dense structure. Cast aluminum chills are used almost exclusively at M.I.T., coated with a rosin-talc wash (Table 4). For castings about ½-in. thick or over, extensive chilling is employed to achieve dependably high mechanical properties within the casting. For thinner castings, these same properties can be guaranteed without extensive chilling.[3,4]

TABLE 4 — CHILL WASH FOR MAGNESIUM ALLOYS

Ingredients	Amounts
Denatured alcohol	1 gallon
Talc (white)	4½-lb
Rosin	7 oz.
Boric Acid	3½-oz.

from The Dow Chemical Co.[7]

Figure 2 shows the mold for producing a high strength housing casting, the research upon which was reported in detail earlier.[4] Extensive chilling was employed, and the maximum distance from riser contacts to chill edges was 2 in. The rough casting is shown in Fig. 3. Use of the chilling and risering practice shown permitted producing the casting in AZ91C alloy with average mechanical properties of 43,500 psi tensile strength, 23,800 psi yield strength and 3 per cent elongation. These properties compare with those obtained in a similar casting produced by more conventional risering practice of 24,200 psi tensile strength, 16,500 psi yield strength and 1 per cent elongation.

By careful foundry techniques, it should be possible to produce AZ91C alloy castings with guaranteed minimum mechanical properties in specified locations of at least 37,000; 18,000; 2*. These properties represent an improvement of 46 per cent in tensile strength, 20 per cent in yield strength and 170 per cent in elongation over present specifications of 25,500; 14,500; ¾ (Table 5). It is re-emphasized that to achieve high properties in heavy castings requires extensive chilling and risering, as shown in Figs. 2 and 3. However, much less chilling is required in thinner castings.[3,4]

FLUIDITY STUDIES

To take full advantage of the lightness and strength of magnesium alloys, designers are requesting sand castings that are thinner than can be made by ordinary foundry techniques. The difficulty in producing thin castings (under ⅛-in.) is due primarily to inadequate fluidity of the metal, i.e., the metal

*The shorthand 37,000; 18,000; 2 is used to represent 37,000 psi tensile strength, 18,000 psi yield strength, 2 per cent elongation.

TABLE 5 — SOME MECHANICAL PROPERTIES OF CAST MAGNESIUM ALLOY AZ91C

Test Bars	Tensile Strength, psi	Yield Strength, psi	Elong., %
0.505 Cast to Size Test Bar (minimum)[a]	34,000	16,000	3
Test Bars Cut from Casting (average)[a]	25,500	14,500	¾
Test Bars Cut from Casting (minimum)[a]	17,000	12,000	0
Premium Quality Castings (minimum)[b]	37,000	18,000	2

a — QQ-M-56 (a), Sept. 3, 1957.
b — Reference 2.

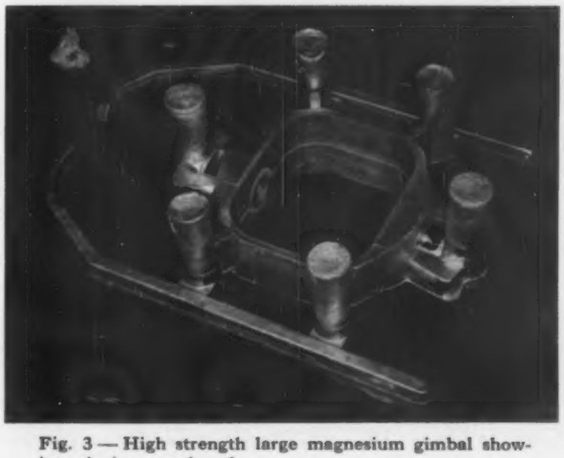


Fig. 3 — High strength large magnesium gimbal showing rigging employed.

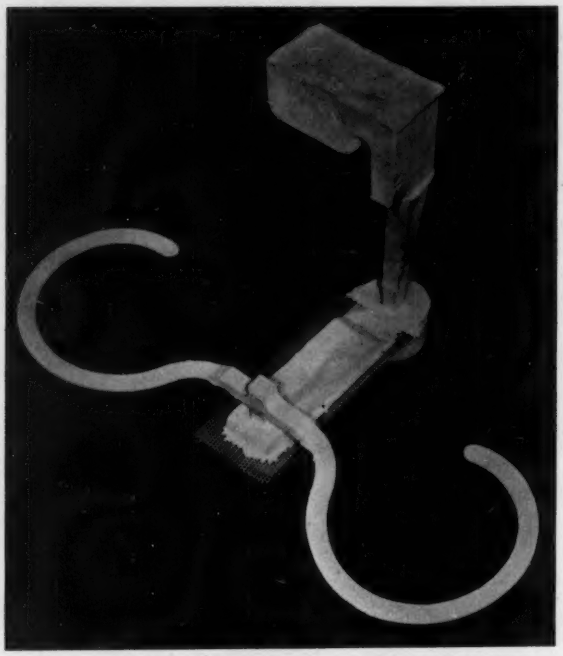


Fig. 4 — Double spiral fluidity casting with gating system.

solidifies before completely filling the thin mold cavities. Two practical ways to obtain increased fluidity is by choice of alloy composition and by providing additional superheat to the melt. However, there are limitations to these techniques and few foundries can produce magnesium castings with extensive sections much less than 1/8-in. thick.

Previous studies[6,9] at the M.I.T. foundry laboratory, on the improvement of the fluid flow characteristics of aluminum alloys, showed that fluidity could be increased by a factor of three by application of mold coatings. Hexachloroethane and amorphous carbon were the coatings found to be most effective, and these were tried on several commercially important magnesium alloys.

Figure 4 illustrates the double spiral type fluidity test used for much of this study. Essential features are 1) a carefully designed gating system with screen and 2) identical twin spirals. This permits coating one spiral and leaving the other uncoated as a control. Details of research and check work done in developing this special test have been published.[6] All work reported herein was done with green sand molds.

Data, showing the effect of amorphous carbon and hexachloroethane on fluidity of AZ91C alloy, are shown in Fig. 5. Amorphous carbon was applied from a "smoking" oxyacetylene torch, and hexachloroethane was deposited from an ether solution. Both were applied in thicknesses of approximately 0.003 in., although the thickness of amorphous carbon was not measured in all instances.

Amorphous carbon coatings improved fluidity by as much as 100 per cent at the lower pouring temperatures, and 50 per cent at the higher temperatures. In all instances, amorphous carbon was about twice as effective as hexachloroethane. Figure 6 shows representative spiral castings, showing the effect of amorphous carbon and pouring temperature on

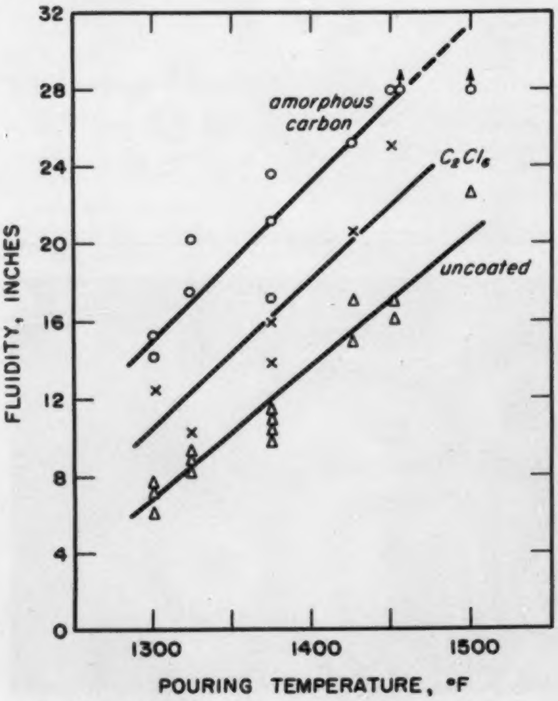


Fig. 5 — Amorphous carbon and C_2Cl_6 mold treatment effect on fluidity of AZ91C alloy.

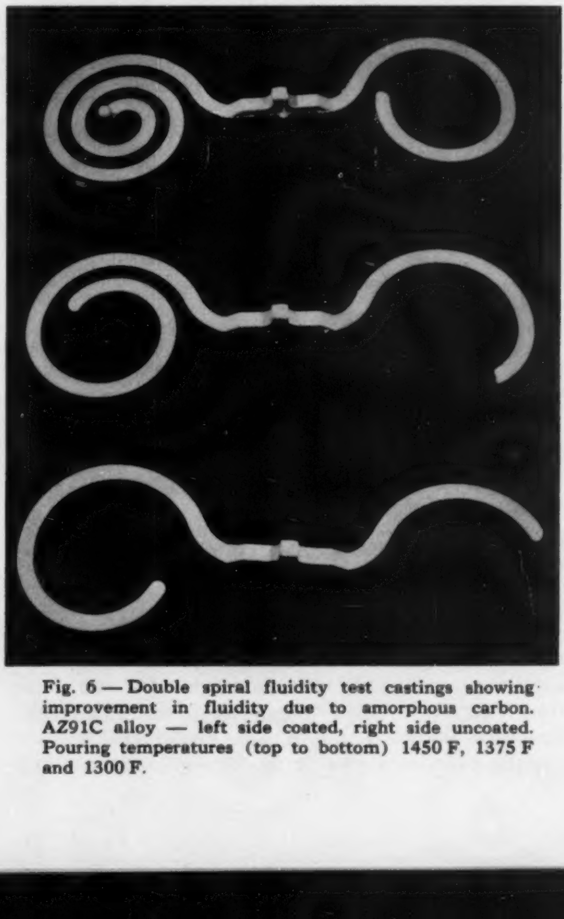


Fig. 6 — Double spiral fluidity test castings showing improvement in fluidity due to amorphous carbon. AZ91C alloy — left side coated, right side uncoated. Pouring temperatures (top to bottom) 1450 F, 1375 F and 1300 F.

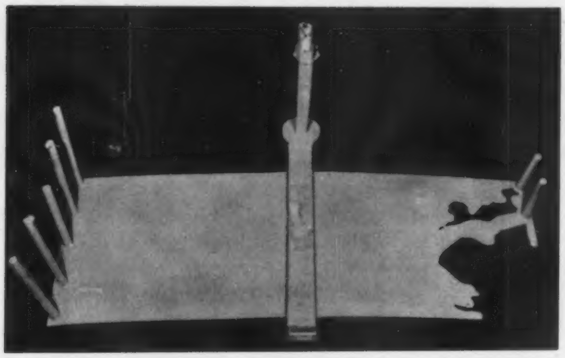


Fig. 7 — Amorphous carbon mold treatment effect on fluidity of AZ91C alloy. Right side of plate uncoated, left side coated with 0.003 in. layer of amorphous carbon. Pouring temperature 1500 F. Each plate 10 x 12 x ⅛-in. thick.

fluidity. Figure 7 shows how the carbon aids in filling a thin, flat, plate casting.

Work conducted to date at M.I.T. on mold coatings for magnesium has been of a relatively limited scope. Effect of coating thickness and coating technique have not been examined, and only limited studies have been made of coatings other than those described above. However, on the basis of the results obtained, amorphous carbon is the treatment currently used to promote fluidity in thin prototype castings (amorphous carbon is not new as a "fluidity promoter" and has been used in some magnesium foundries for a number of years).

In the course of this work, a study was also made of the effect of amorphous carbon mold coatings on fluidity of other magnesium alloys, including AZ92A (9.0% Al, 2.0% Zn, 0.15% Mn, bal Mg), ZK51A (4.5% Zn, 0.75% Zr, bal Mg), and KIA (0.75% Zr, bal Mg). In each case similar improvements in fluidity were obtained (the increase in fluidity for all alloys approached 100 per cent at the lower pouring temperatures). At the same time, comparison of control (uncoated) spirals showed the relative fluidities of the various magnesium alloys tested (Fig. 8). Results agree well with qualitative foundry experience; the alloys rated in order of decreasing fluidity (at a given pouring temperature) are 1) pure magnesium, 2) AZ92A, 3) AZ91C and 4) ZK51A and KIA.

PROTOTYPE CASTINGS

Center Gimbal

The center gimbal casting (Fig. 9) is representative of the simpler types of gimbal castings produced for missile applications. It has a uniform wall thickness of ¼-in., except for the flange section which is ½-in. The casting is a hemisphere with a 7½-in. radius. Net weight is 7½-lb.

The mold for this casting was entirely of green sand. Five risers were used, four of which were side risers. Ring chills were placed around the upper portion, and additional chills were located on the casting circumference midway between the risers. Bosses were also chilled.

Ten test bars were cut from the casting in locations typical of the casting as a whole (some of these are shown in Fig. 10). Resultant mechanical properties average 38,400; 21,400; 3½. Several individual bars possessed relatively low ductility [Table 6 (although substantially above present minimums)], but had these been in critical areas from a standpoint of ductility, minor changes in rigging could have been made to correct this.

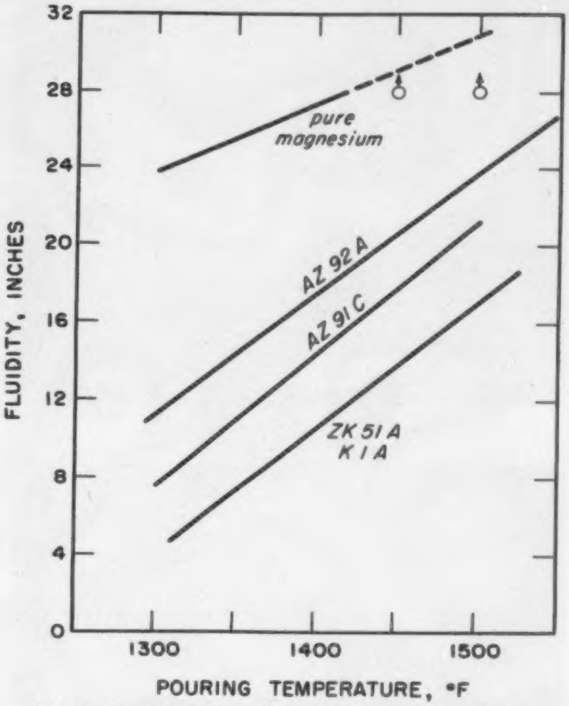


Fig. 8 — Comparison of fluidity of several commercial magnesium alloys (AZ91C, AZ92A, ZK51A and KIA) and pure magnesium (Additional data have resulted in a slight displacement of several of the above curves from those in the report on which this paper is based[2]).

Fig. 9 — Center gimbal showing rigging employed.

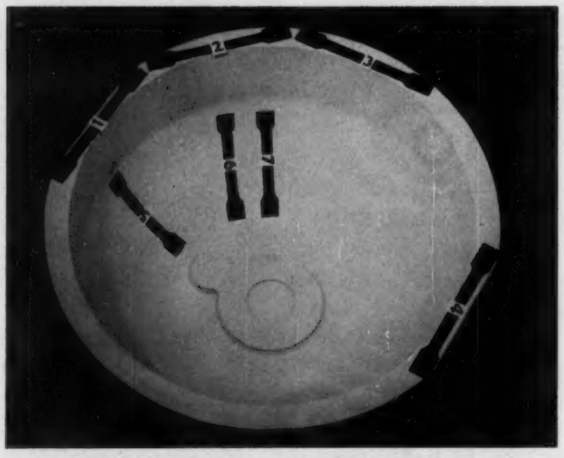
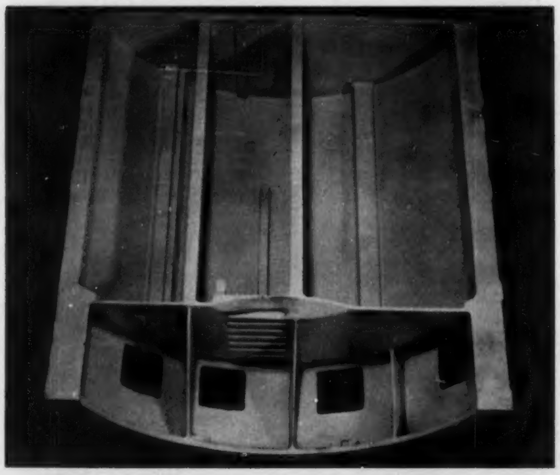


Fig. 10 — Test bar locations in center gimbal.

Fig. 11a and b — Finished casting, electronics package.



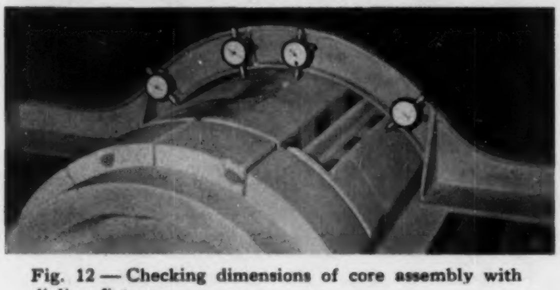


Fig. 12 — Checking dimensions of core assembly with dialing fixture.

TABLE 6 — MECHANICAL PROPERTIES OF HIGH STRENGTH CENTER GIMBAL

Bar No.*	Ultimate Tensile Strength, psi	Yield Strength, psi	Elong., %
1	39,400	20,700	4½
2	41,600	25,200	6
3	34,700	21,000	2
4	41,700	20,200	6
5	37,400	**	1½
6	36,900	**	3
7	40,100	**	3
8	39,600	**	2½
9	35,700	**	3
10	37,200	20,000	4½
Avg.	38,400	21,400	3½

*Bar No. refers to test bar locations, shown in Fig. 10.
**Yield strength not obtained.

Electronics Package Casting

In addition to seeking castings with high mechanical properties and thin sections, missile designers often require closer dimensional tolerances in sand castings than are ordinarily considered feasible. These close tolerances are necessary to save space and weight or to minimize machining. One such casting, produced in the M.I.T. foundry laboratory, is shown in Fig. 11. Dimensional tolerances were $\pm\frac{1}{64}$-in. on the radius of the inner wall, and $\pm\frac{1}{32}$-in. in other locations. The casting was made of AZ91C alloy. Total finished weight was 14 lb. Overall dimensions were approximately 17 x 19 x 6 in. with wall thickness $\frac{1}{8}$-in.

All critical dimensions were produced by cores (urea-formaldehyde). Precise setting of internal cores was essential to achieve dimensions, and a contour template and dialing fixture were used to aid in doing this. Figure 12 illustrates final checking of one core. Before pouring, the mold cavity was blackened with a reducing oxyacetylene flame to aid fluidity of the metal (Fig. 13).

Extensive chilling and risering were employed to assure soundness (Figs. 14 and 15), and pouring was from two separate sprues. Four castings were produced and checked for dimensions. All critical dimensions were found to vary from casting to casting by less than 0.010 in. Mechanical properties of one casting which was extensively tested average 34,000; 20,700; 1½.

Inner Gimbal

Still another class of castings of interest to missile designers involves cored passageways for carrying coolant or other fluids; the "inner gimbal" is representative of this type of casting. Figure 16 shows an early design of the casting; length of each side is about 12 in. and net weight is 8 lb. 10 oz. In this case, the grooved channels on each surface were later covered by a plate, and the resultant internal passageways carried heat exchanging fluid.

In a later design (Fig. 17), the grooved channels were replaced by stainless steel tubes cast integrally within the casting. This casting was made entirely in core sand. The stainless steel tubes were mounted on the internal core before core assembly (Fig. 18).

Fig. 13 — Completely carbonized core and mold surfaces.

Fig. 14 — Casting at shakeout.

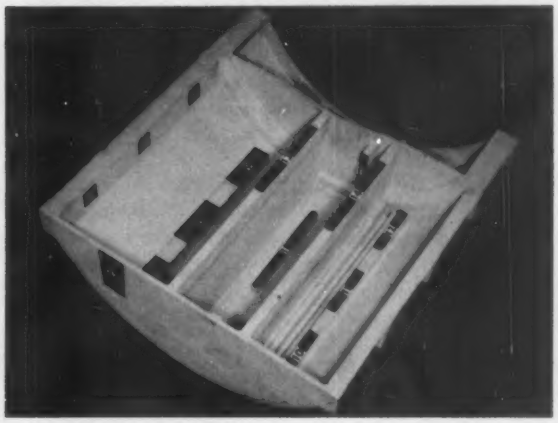


Fig. 15 — Chill locations.

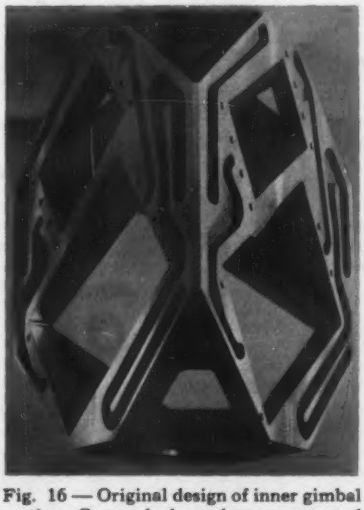


Fig. 16 — Original design of inner gimbal casting. Grooved channels were covered by a plate. Resultant passageways carried heat exchanging fluid.

Fig. 17 — Final design of inner gimbal casting. Internally cast stainless steel tubing replaces grooved channels.

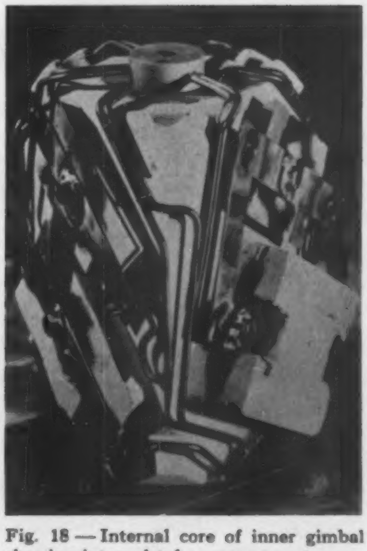


Fig. 18 — Internal core of inner gimbal showing internal tube arrangement.

Fig. 19 — Inner gimbal with internal tubes after shakeout.

Dimensional tolerances of tube locations ($\pm 1/32$-in. in the external faces) were maintained by brackets which were set by height gages. The brackets were bolted to the interior of the core, and all tubes and bolts were brazed to the brackets to prevent movement.

The casting was produced with 5 risers, two of which were riser gated (Fig. 19). To assure that moisture would not condense on the tubing before casting, the entire mold assembly was preheated to 250 F before pouring; the mold was poured immediately on removal from the oven. After rough cleaning, each face was fully machined; machining removed all brackets and exposed the tube locations, as shown in Fig. 17.

SUMMARY

This paper summarizes techniques employed in the M.I.T. foundry laboratory for producing prototype magnesium castings for missile applications. The paper deals primarily with AZ91C alloy (8.7% Al, 0.7% Zn, 0.15% Mn, bal Mg).

Careful foundry practice (including control of melting, gating, chilling, risering and other foundry variables) has been shown to result in sound castings, with strengths and ductilities substantially higher than are obtained by usual foundry procedures. For example, in AZ91C alloy minimum mechanical properties can be guaranteed in intricate castings to be at least 37,000 psi tensile strength, 18,000 psi yield strength and 2 per cent elongation. These compare with average properties currently expected of 25,500 tensile strength, 14,500 yield strength and 3/4 per cent elongation.

Mold coatings (amorphous carbon and hexachloroethane) improve fluidity of magnesium alloys by as much as 100 per cent, and permit production of thinner, more intricate castings than is otherwise feasible.

Application of careful foundry techniques to production of several prototype castings has been described. The castings were 1) a simple hemispherical gimbal, 2) a large, thin, casting requiring close control of dimensions ($\pm 1/64$-in. in some locations) and 3) a gimbal casting requiring integrally cast tubes for heat exchange purposes.

ACKNOWLEDGMENT

The authors wish particularly to express their appreciation to the many members of the staff of M.I.T. Instrumentation Laboratory for support of this work through the U.S.A.F., Contract No. AF 04(647)-303. Thanks are also due Mr. Richard Strachan who conducted important parts of the experimental work described, to Mr. David Poirier and Mr. Thomas Callahan and to the foundry personnel under direction of Mr. Edwin Backman. Illustrations were by George E. Schmidt.

REFERENCES

1. "Summary Report No. 1, Foundry Techniques," Instrumentation Laboratory, M.I.T., U.S.A.F., Contract No. AF33(616)-3892, Task 50496, and U.S.A.F. Contract No. AF04(645)-9.
2. "Summary Report No. 2, Foundry Techniques," Flemings, M. C., Poirier, E. J., Strachan, R. W. and Taylor, H. F., Instrumentation Laboratory, M.I.T., U.S.A.F., Contract No. AF04(647)-303.
3. Flemings, M. C., Strachan, R. W., Poirier, E. J. and Taylor, H. F., "Performance of Chills on High Strength Magnesium Alloy Sand Castings of Various Section Thicknesses," AFS Transactions, *vol. 66*, pp. 336-343 (1958).
4. Flemings, M. C., Strachan, R. W., Poirier, E. J. and Taylor, H. F., "Rigging Design of High Strength Magnesium Alloy Castings," AFS Transactions, *vol. 66*, pp. 241-246 (1958).
5. Flemings, M. C., Norton, P. J. and Taylor, H. F., "Rigging Design for a Typical High Strength-High Ductility Aluminum Alloy Casting," AFS Transactions, *vol. 65*, pp. 550-555 (1957).
6. Flemings, M. C., Conrad, H. F. and Taylor, H. F., "A Fluidity Test for Aluminum Alloys; Tripling Fluidity with a New Mold Coating," AFS Transactions, *vol. 67* (1959).
7. "Molding and Core Practice for Magnesium Foundries," The Dow Chemical Co., Magnesium Div., Bulletin 141-29.
8. "Open-Pot Melting Practice for Magnesium," The Dow Chemical Co., Magnesium Div., Bulletin DM26C (1949).
9. Foundry Section, Metals Processing Division, Dept. of Met., M.I.T., "Research on Parameters Influencing Fluidity in Aluminum Base Alloys," Final Report, Dept. of the Army, Ordnance Corps Contract No. DA-19-020-507-ORD-4503 (July 1, 1958).

ALLOY 20 STAINLESS STEEL PRODUCTION AND MECHANICAL PROPERTIES

by Leroy Fink

ABSTRACT

One of the most troublesome problems in the production of Alloy 20 stainless steel (CN7MCu) is hot-shortness of castings. A study showed this could be combated by addition of a combination of vanadium, silicon, titanium, aluminum, boron and iron. A study of mechanical properties on a statistical basis with two sigma deviation shows the minimum mechanical properties to be 60,000 psi ultimate tensile strength, 27,000 psi yield strength. The study also indicates carbon content control is critical for the cited properties.

INTRODUCTION

Alloy 20 stainless steel is a fully austenitic chromium-nickel stainless steel alloy containing both copper and molybdenum. It is designed to have increased resistance to sulfuric acid. It was originally developed as a cast alloy, but is now available in both cast and wrought forms. Since it is fully austenitic, it has the usual sensitivity to hot-shortness that all low carbon fully austenitic chromium-nickel stainless steel alloys have when cast into sand molds.

In addition, it has its own particular type of hot-shortness sensitivity. The lead content has to be carefully controlled to 0.002 per cent maximum, and the total content of the silicon plus copper should not exceed 4.50 per cent.

When all precautions are taken in production, such as limited use of returns or even virgin heats, use of armco ingot iron, electrolytic copper and the purest of ferro-alloys in order to insure that the lead content does not exceed 0.002 per cent, and when the best laboratory control is exercised to see that the silicon plus copper contents do not exceed 4.50 per cent total, it has often been found that some heats are still sensitive.

The author's company has been a producer of Alloy 20 for 22 years. A study of this problem of extreme sensitivity was started in 1952. The first step in this research program was developing a tool and/or method of evaluation of different heats.

FLAME TEST

Several methods were tried, but since it had been noted that sensitive heats could often be detected while burning off the risers or gates a flame test was taken as the tool. This flame test procedure, as worked out over a period of time, consists of pouring a standard keel block in a core sand mold (Fig. 1). When this keel block has cooled one triangular end is ground smooth on a stand grinder. Care must be taken to see that the area being ground does not become overheated during grinding.

TABLE 1 — CHEMICAL COMPOSITION RANGE OF CAST ALLOY 20

Element	Per Cent
Carbon	0.07 max.
Manganese	2.00 max.
Silicon	1.50 max.
Chromium	19.00-22.00
Nickel	27.50-31.00
Molybdenum	1.80- 2.50
Copper	3.00- 3.50

This keel block is then placed in a jig with the ground face up. An oxy-acetylene torch with a number 150* heating tip is placed in a holder on the jig and the flame is played on the ground face. The jig holds this torch a fixed distance away from the face being heated. The face is heated for a set length of time in order to control as many variables as possible. It is desired to heat the metal to a temperature just below the solidus and not induce incipient melting. After cooling, the keel bar is examined for severity and extent of cracking.

The face may be cleaned by buffing lightly with fine emery paper. The more sensitive the heat the greater the cracking will be. In a sensitive or ex-

*A No. 150 heating tip delivers 150 cu ft/hr of both oxygen and acetylene.

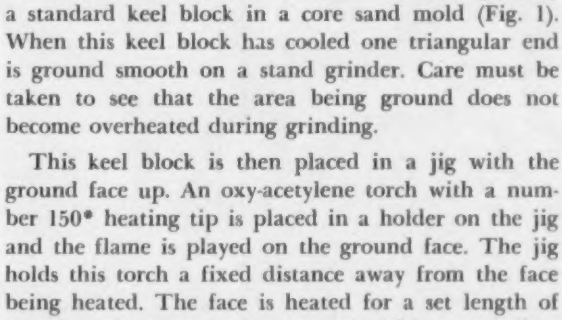


Fig. 1 — Keel block used in flame test evaluation.

L. FINK is Supvr. Met., Operations, Electric Steel Fdy. Co., Portland, Ore.

TABLE 2 — RELATIVE GRAIN SIZES OF ALLOYING AGENTS

Element	Atomic Dia., Angstrom
Iron	2.48
Nickel	2.48
Chromium	2.50
Silicon	2.34
Columbium	2.85
Carbon	1.42
Aluminum	2.856
Titanium	2.91
Vanadium	2.63
Boron	—

tremely "hot short" heat, the cracks will be noted at grain boundaries during the heating. A heat which is not sensitive will not develop any cracks. Using this test on every heat it was soon determined that heats varied in sensitivity markedly and randomly. No correlation could be found between the heat analysis and cracking.

WELDING SENSITIVITY

Rollason and Bystram,[1] in a discussion on the problem of welding sensitivity of full austenitic Cr-Ni alloys, pointed out

> ". . . in the absence of further evidence it may be inferred that the weakness of the grain boundaries does not result from precipitation but is caused by the concentration of some element at the grain boundary while still remaining in solution. For temper brittle steels McLean[2] and McLean and Northcott[3] have shown that in a solid solution the composition of the crystal may be different from that of the grain boundaries. In a weld this difference in composition is intensified by coring.
>
> "The grain boundaries can be considered as the transition lattice in which some iron atoms will occupy larger and some smaller volumes than a perfect lattice. The resulting local stresses represent a high energy and therefore instability in the structure. This energy may be reduced by placing atoms with large atomic radii in the spaces between the atoms occupying large volumes, i.e., to prevent rattling of atoms. In a similar way very small atoms may be put into the small spaces. Consequently, the energy of the whole mass will be reduced if elements having an unfavorable size factor relative to the solvent according to Hume Rothery criterion, move from the lattice in the crystal to more suitably matched spaces in the boundary region.
>
> "The relative sizes of relevant alloy elements are given in Table 2 from which it will be seen that nickel and chromium are likely to be fairly stable in the lattice. On the other hand, silicon, columbium and carbon because of their size are likely to diffuse to the grain boundary. The combination of small silicon and carbon atoms and large columbium atoms produces in the transition zone of the boundary a stability associated with an increase in strength at the elevated temperature. To become really effective certain ratios of columbium and silicon may be necessary.
>
> "The melting point of columbium and carbon are high and this might be expected to increase the strength of the boundary. The melting point of silicon, however, is lower than iron and in the absence of columbium may tend to form incipient $FeSi_2$ or FeSi with melting points about 1200 C. The results already obtained indicate that silicon is an important factor in promoting cracking of austenitic alloys, and is likely to have a major influence on crack formation in the plain 18-13 alloy. The columbium in the 18-13-1 alloy will tend to counterbalance the effect of silicon and reduce cracking, which agrees with the results obtained. The addition of more than 0.09 per cent carbon forms a padding in the vicinity of the silicon atom and reduces cracking."

COLUMBIUM ADDITION

In light of the above discussion, columbium was added to several heats of Alloy 20 in an attempt to study the validity of what was said. Flame test studies of these heats showed that in the production of cast Alloy 20 columbium was not beneficial in reducing the sensitivity.

One steel company has vividly demonstrated that the addition of mischmetal to Alloy 20 makes it readily forgeable, and the wrought Alloy 20 produced today is made with mischmetal additions. Part of this research program also included a study of effects of mischmetal addition. Again, the flame test indicated that there was no benefit obtained from use of this material on the cast alloy. All of the evaluation tests reported here were made on test bars from the base heat as well as on bars poured with metal to which the material being tested had been added.

As the investigation continued a study of atom sizes showed that aluminum, titanium and vanadium, among other elements, have atomic diameters larger than chromium and nickel and about the same size as columbium. Additions of vanadium were investigated at this time, since it was noted that a nickel base proprietary alloy similar to fully austenitic stainless steel contained more than 0.20 per cent vanadium. One of the materials used in the study of vanadium addition was a proprietary material made up of vanadium, titanium, aluminum, silicon, boron and iron.

It was soon fairly evident that test bars poured with this addition showed much less sensitivity to the flame tests than did the heats made without it. The research was continued to see if any certain element found in the alloying material was more beneficial when used separately. This included the use of ferrotitanium, aluminum and ferro-vanadium by themselves. The conclusion from this study was that the use of the combination resulted in best results for minimizing sensitivity.

Figure 2 shows the results of flame tests made in this phase of the program. The resulting cracks are brought out by use of fluorescent magnetic particles and black light. Patents No. 2,811,438 and 2,867,533 have been issued to cover the use of the material in fully austenitic stainless steels to combat hot-short-

ness. One of the ways hot-shortness is most detrimental in castings is with regard to weldability. It was found that those heats which were most sensitive to the flame tests were also difficult to either weld repair or to weld into an assembly. The use of the additive minimized the problem of weldability.

Further work showed that the weldability correlates with the flame test to a great extent. At the present time a heliarc bead test has been devised for a more critical evaluation of the weldability of heats. The reason for the effectiveness of this additive material in combatting hot-shortness is not definitely known at this time. Further research is being carried out to determine this. One possible mechanism is nucleation, since the elements used could be considered as sources of nucleii. A grain size study showed some slight indication of this.

DEOXIDATION

One other mechanism may be more thorough deoxidation. The elements in the material all are very effective deoxidizers and are used separately as such.

At the 1956 Electric Furnace Conference, a paper presented by Perkins and Binder[4] on production of Type 310 alloy pointed out the effect of various deoxidizers on the Type 310 wrought material. Among

Fig. 2 — Results of flame tests made after (1) no addition, (2) boron-free additive (titanium, silicon, aluminum, vanadium, iron), (3) ferro-titanium, (4) ferro-vanadium, (5) ferro-titanium plus ferro-vanadium and (6) special additive (titanium, silicon, aluminum, vanadium, boron, iron). Photograph taken after fluorescent magnetic particle examination under black light.

the deoxidizers used in this study were aluminum, titanium, silicon and vanadium. During the discussion period it was asked if it was thought that these deoxidizer effects might be additive, and the authors said that they thought they would be.

At the present time a study is being made of oxygen contents of heats before and after using the additive. Use of the additive may be effective through a combination of all three methods: better deoxidation, nucleation and the presence of atoms of larger size which are able to fit in the transition zone of the boundary and thus impart a stability which may be associated with an increase in strength.

MECHANICAL PROPERTIES

In 1958 an application was made to the A.S.M.E. Boiler Code for a special case for Alloy 20 to be acceptable to the boiler code. Included in the application were data with regard to the minimum mechanical properties expected from Alloy 20. To determine these statistical data, processing methods and statistical analysis were used on the results of mechanical property tests on 118 heats of Alloy 20.

The statistical study consisted of making compilations of each individual item of mechanical property data and chemical analyses with regard to every other item. The effect of carbon, manganese, silicon and all the other elements were individually evaluated with regard to tensile strength, yield strength and ductility. A statistical evaluation of the mechanical properties showed that these 118 heats fell well under a normal distribution curve. This would indicate that under the present control it would be expected that the results now being obtained could be repeated with a fair degree of accuracy.

The median number of heats when you study 118 would be 59. In examination of the statistical data it was found that the mode of heat 59 has a tensile strength of 65,000 psi and a yield strength of 30,500. The average tensile and yield strengths of the 118 heats was 65,570 psi and the yield strength was 30,400 psi.

The normal method used to determine the minimum mechanical properties included in the A.S.T.M. Specifications has been that obtained with a two sigma distribution. By this it is meant that 95.4 per cent of all the data fell under the normal distribution curve. Inasmuch as we are only interested in the 2.3 per cent which are below the two sigma distribution, this means that 97.7 per cent of all the heats will normally be in excess of the minimum properties as set forth.

A study of the 118 heats shows that an ultimate tensile strength of 60,000 psi with a yield strength of 27,000 psi would be the minimum values on a two sigma distribution. A statistical examination of the mechanical properties with relation to chemistry showed that carbon content had a great influence while no other element showed any influence. In order to make sure that the tensile strength exceeds 60,000 psi and yield strength 27,000 psi the carbon content has to be at least 0.05 per cent.

Inasmuch as the maximum carbon content for the alloy is 0.07 per cent, this makes the carbon control a critical one in order to meet these mechanical properties. After noting from the data that the carbon had to be 0.05 per cent, several heats were made with the carbon content less than 0.05 per cent. Test bars of the base metal and metal from the same heat with carbon added were tested in tension. The results of the tension test confirmed the need for the carbon content to be over 0.05 per cent (Table 3). It is interesting to note that the carbon content is critical in light of the discussion by Rollason and Bystram[1].

TABLE 3 — CARBON CONTENT EFFECT ON MECHANICAL PROPERTIES OF ALLOY 20

		Mechanical Properties		
Heat No.	Carbon Content, %	Tensile Str., psi	Yield Str. (0.2% offset)	Elong., in 2 in., %
20-1606	0.04	58,200	25,400	49
20-1606C	0.07	62,700	26,900	50
20-1616	0.04	56,500	24,750	44
20-1616C	0.08	66,750	29,250	47.5
20-1619	0.02	62,000	27,000	51.5
20-1619C	0.06	66,200	29,400	41.5
20-1625	0.04	62,250	27,400	45.5
20-1625C	0.08	68,200	29,400	46.5
20-1630	0.04	60,500	26,600	43
20-1630C	0.08	64,200	27,100	50

CONCLUSIONS

Cast Alloy 20, a fully austenitic chromium-nickel stainless steel containing molybdenum and copper exhibits more than usual hot-short sensitivity. This sensitivity may be minimized by the use of a titanium-aluminum-vanadium-silicon-boron material. The exact mechanism of the effect is not definitely known. Evidence shows that it may be from more complete deoxidation obtained by the presence of titanium and aluminum from nucleation which may form a finer grain. This is with the possibility that the larger atom size of the vanadium and titanium adds strength to the grain boundary due to the presence of these larger atoms in the transition area of the grain surfaces.

The minimum mechanical properties to be expected for this alloy are 60,000 psi tensile strength, 27,000 psi yield strength and an elongation of 45 per cent. Carbon content in this alloy is critical in order to meet the above minimum mechanical properties, and should be held within the range of 0.05-0.07 per cent.

ACKNOWLEDGMENT

Thanks and appreciation are given to the management of the Electric Steel Foundry Co. for permitting the information to be published.

REFERENCES

1. "Hot Cracking of Austenitic Welds," Rollason & Bystram, *Journal of Iron & Steel Institute, vol. 169* (Dec. 1951).
2. D. McLean, *Journal of the Institute of Metals, vol. 73*, p. 791 (1947).
3. D. McLean & L. Northcott, *Journal of the Iron & Steel Institute, vol. 158*, p. 169-177 (1948).
4. R. A. Perkins and W. O. Binder, *Electric Furnace Steel Proceedings, vol. 14*, p. 123-140.

GATING AND RISERING OF DUCTILE IRON

A panel discussion

ABSTRACT

This panel discussion covers various phases of gating and risering of ductile iron.

The effect of composition of gating and risering characteristics is covered in one of the discussions. The variable which affects shrinkage most is its carbon equivalent, which should be controlled at or above the eutectic point for maximum riser efficiency. Magnesium and other carbides should be held to the lowest possible level to produce a ferritic ductile iron for maximum riser efficiency. Dross forming elements should be held to the lowest practical limit to improve flow characteristics of the molten metal in the gating system and in the mold.

Gating and risering green sand ductile iron castings as dealt with in the second discussion were made on jolt squeezer or jolt rollover. The runner system is made large enough to permit choking between sprue and riser, to create a swirl in the riser or to use a number of pressure gates. Dead bobs are not effective, and are used to feed isolated bosses or heavy sections only or to feed metal past an isolated section that it may set up free of carbide.

Dry sand mold gating and risering is the concern of the third discussion. Steps and procedures are presented for rigging the pattern, core box and gating and risering system for a new ductile iron casting. Consideration is given to chills, chemical control and dross. Several examples of castings are presented, including a compressor cylinder body, a turbine inlet casing and a compressor inlet scoop.

Shell molded ductile iron castings gating and risering for vertical pouring is presented in the fourth discussion. Formulas for pouring time, effective sprue height, coke area calculation, runner size calculation, runner gate area calculation, total ingate size calculation and riser and riser connection size calculation are given. A typical example of calculating a shell mold job using the formulas is given by the author.

DUCTILE IRON COMPOSITION EFFECT ON GATING AND RISERING CHARACTERISTICS

by J. A. Davis

INTRODUCTION

The variable which has the most effect on gross shrinkage of ductile iron is its carbon equivalent. Other elements in ductile iron may affect the gating and risering of the irons in various ways. The effects of the various elements are discussed in the following sections.

J. A. DAVIS is Engr., Proc. Met., Battelle Memorial Institute, Columbus, Ohio.

CARBON EQUIVALENT (CARBON, SILICON AND PHOSPHORUS)

The carbon equivalent (C.E.) of ductile iron is generally calculated as the sum of the total carbon, plus 1/3 of the silicon, plus 1/3 of the phosphorus in the iron. As the carbon equivalent increases, the amount of graphite in the iron increases and less risering is required.

Increasing the carbon equivalent to reduce the amount of metal needed in the risers is effective up

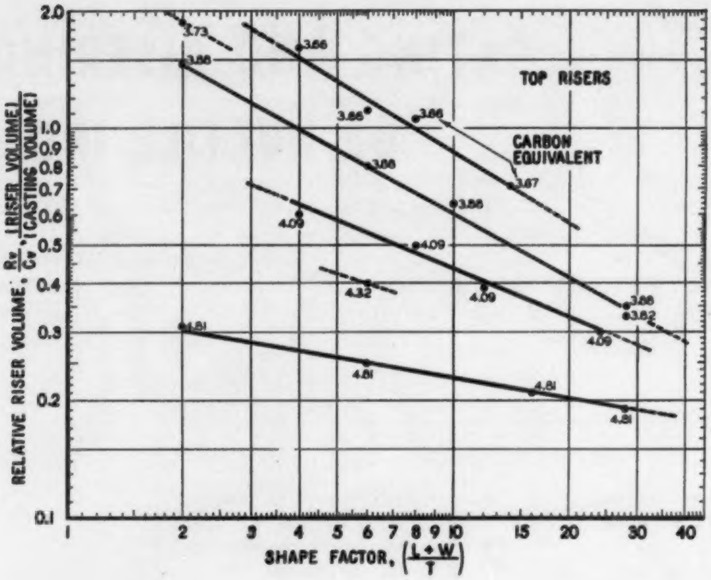


Fig. 1 — Relationship between riser volume and shape factor for ductile iron (Bishop and Ackerlind data).

to an upper limit of about 4.3 per cent C.E. This is about the eutectic composition. If the carbon equivalent is much above the eutectic composition, nodules of graphite may float in the liquid metal and become concentrated near the cope surface of the castings.

As the carbon equivalent is lowered, shrinkage of the iron during solidification increases 1) as the result of the availability of less total carbon to form graphite and, 2) as a result of the fact that larger percentages of the total carbon present form massive iron carbides rather than graphite. If all of the carbon forms carbides, a white iron of high shrinkage results.

A relationship between the carbon equivalent of ductile irons and the sizes of risers required for simple castings made in green sand molds is shown in Fig. 1. The riser volume divided by the casting volume is plotted against the shape factor. The shape factor of the casting is defined as the length plus the width divided by the thickness of the casting.

The effect of carbon and silicon content on the tendency of a ductile iron to form sponge-type shrinkage is shown in Fig. 2.

COMPOSITION EFFECT

Magnesium Content

When the magnesium content of cast iron is above the amount necessary to produce nodules of graphite, the excess acts as a powerful stabilizer of massive carbides and tends to produce white iron structures and increased shrinkage. Inoculation practice generally can be adjusted to prevent the formation of white iron structures.

Excessive amounts of magnesium also increase the amount of dross formed in the metal. Large amount of dross will interfere with the flow of the molten metal in the gates, runners and thin sections of the castings. The magnesium content of the metal should be controlled instead of attempting to remove the dross in the gating system.

Sulfur Content

The sulfur content of metal for the production of ductile iron is generally controlled to low levels, because it is not economical or practical to use magnesium for desulfurizing. If excessive amounts of sulfur are present, larger additions of magnesium will be necessary. The magnesium sulfide will form films on the molten metal, and the films will interfere with the flow of the molten metal.

Tramp Elements

Large amounts of carbide stabilizing elements (such as chromium and vanadium) will tend to cause white iron structures and high shrinkage in cast irons. However, these elements are generally held to low levels for other reasons. Controlled amounts of promoters of pearlite (e.g., manganese or tin) usually do not contribute to inceased shrinkage.

There are a large number of tramp elements which must be controlled to low levels to permit the formation of proper graphite nodules. When the tramp elements are controlled to sufficiently low levels to permit the production of high quality ductile iron, the tramp elements should have little effect on gating and risering practice.

SUMMARY

The carbon equivalent of ductile irons should be controlled at or above the eutectic point for maximum riser efficiency.

Magnesium and other carbide stabilizers should be held to the lowest possible level in order to produce a ferritic ductile iron for maximum riser efficiency.

Dross forming elements (such as magnesium and sulfur) should be held to the lowest practical limit to improve the flow characteristics of the molten metal in the gating system and in the mold.

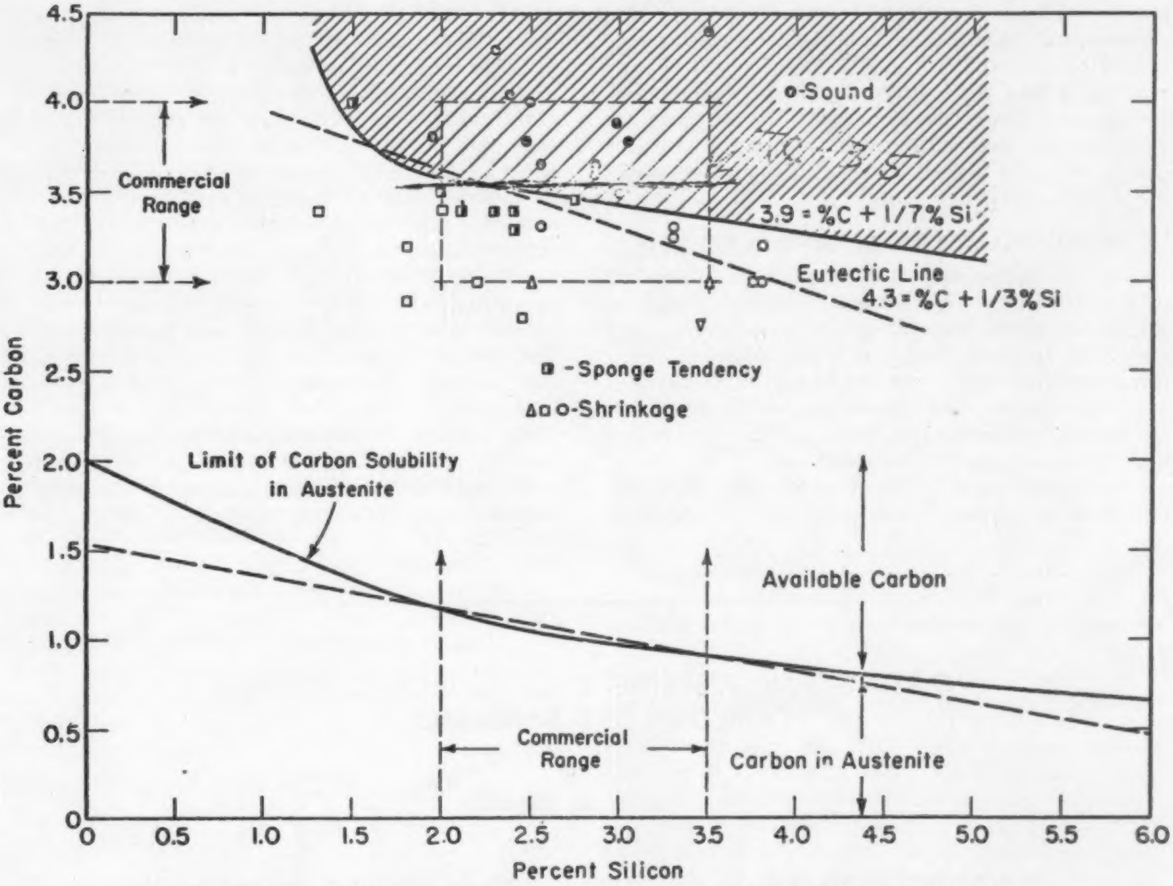


Fig. 2 — Carbon and silicon contents effect on sponge type shrinkage. Also, effect of silicon content on carbon solubility in austenite at 2100 F (C. Reynolds, J. Maitre and H. Taylor).

GREEN SAND DUCTILE IRON CASTINGS GATING AND RISERING

by J. C. McCartney

INTRODUCTION

Nodular or ductile iron produced at the author's company has a section size of 1/4 to 4 in. with weight range from 1 to 120 lb and with a few parts exceeding 120 lb. All castings are made from green sand, on jolt squeezer or jolt rollover. Base iron is tapped at 2850 to 2900 F, inoculated and poured at 2650 to 2550 F with a carbon range of 380-400 and a silicon content of 240-280.

GATING PRACTICE

The gating practice is a carry-over from malleable – mostly trial and error. The runner system is made large enough to permit choking to the satisfaction of the foundry.

Before making a production pattern, trials are made from a wooden experimental pattern or the master to obtain a sound casting. As 90 per cent of the work has been made experimentally prior to production requirements, the gating was determined at that time, photographed and gating data recorded. This method is a great help in proceeding with production patterns. The data and photographs are useful for discussions with the product engineers of any design changes to produce a sound casting, such as gate pads or an increase in section sizes. It has been found that the engineers are more willing to approve the

J. C. McCARTNEY is Malleable Castings Engr., John Deere Malleable Works, East Moline, Ill.

foundry's request for changes if made while in the experimental stage rather than after the casting has been tried and tested.

When a new part enters the plant, the foundry and pattern layout department discuss the part to determine the best gating area to produce a sound casting with the highest yield and the greatest number of units on a match plate.

RISER DIAMETER DETERMINATION

After the gating area is determined, the diameter of the riser or bob is obtained by adding 1½-in. to the vertical width of intake gate on gates under 1 in., and 2 in. to gates over 1 in. The height is twice this diameter. However the height may be reduced to 1½ times the diameter depending on the design of the casting, the method by which the iron enters the mold cavity and the pouring speed.

The runner system is placed on the pattern to permit choking between sprue and riser, to create a swirl in the riser or to use a number of pressure gates. To date, no mathematical formulas to determine the choke area are used.

On the majority of the jobs, the iron enters the mold cavity directly through the riser intake gate. However, it has been found that on some designs when all the iron enters the mold cavity through one area, shrink may be found in front of the riser. To eliminate this type of shrink it is best to add one or more pressure intake gates into the cavity with a portion entering through the riser intake. This is particularly true of ½ to 1½-in. sections.

Dead bobs are not effective, and are used only to feed isolated bosses or heavy section, or to feed metal past an isolated section that it may set up free of carbide.

All castings are sold and, with few exceptions, are used in the as-cast stage; therefore, it is necessary that extra bobs or heaters and controlled dumping to have a carbide-free casting are used.

GATING AND RISERING DUCTILE IRON CASTINGS POURED IN DRY SAND MOLDS

by D. M. Marsh

INTRODUCTION

The steps in procedure are presented for rigging the pattern, core boxes and gating and risering system for a new ductile iron casting. Attention is given to parting of the pattern with consideration for the best metal distribution, quiet pour and placement of risers for feeding heavy sections or hot spots.

The gating system is calculated to provide a choke at the ingates using a 10:9:8 gating ratio. Dam gates are often used to prevent slag inclusions. Where practical, bottom pouring is used to minimize turbulence. The pouring rate is usually fast. In uniform sectioned castings risers are seldom used, and good metal distribution is provided. Castings with isolated heavy sections have risers feeding these sections. If possible, gating is into the risers. Chills are used where the sections cannot be reached with risers.

Carbon and silicon ratios are kept within the sound casting range shown on the Reynolds-Maitre-Taylor diagram from "Effect of the Composition of Nodular Irons on their gating and risering characteristics."

When prints for a new casting are received in the foundry, a conference is held by foundry personnel to establish the plane of parting of the pattern and the gating and risering details. The planning group consists of the foundry superintendent, metallurgist and pattern, molding and coremaking supervisors.

D. M. MARSH is Fdy. Supt., Cooper-Bessemer Corp., Mt. Vernon, Ohio.

Consideration is given to the following features:

1) Dimensions of available flasks. This may control to some extent the placement of downsprues, runner bars and risers or even the plane of parting of the pattern.
2) Convenience to the molding department for ramming the mold. A rigid mold wall is considered essential to produce a sound casting. The pattern is parted to minimize the possibility of soft spots in the mold, if other considerations do not interfere.
3) Will there be sufficient head on the metal to produce a sound casting? This may affect cope depth or the plane of parting of the pattern.
4) The casting design is examined to see a) if a uniform temperature gradient can be established or b) if not, where the casting will have to be fed or chilled.

RISERLESS CASTINGS

If the casting is of reasonably uniform section size, without the likelihood of hot spots, it may be safe to proceed without chills or risers. Use can be made of the rigid mold wall feature of the dry sand molding process. This phenomenon has been reported in detail by the AFS Gray Iron Div. Research Committee.

To maintain an even temperature gradient in castings of uniform section, it is usually necessary to provide good metal distribution by gating into the mold cavity at several locations. If the first metal in

has to travel too far it will lose considerable heat to the mold cavity as it progresses. This will put cold metal in remote sections causing directional solidification which is undesirable if feed metal is not provided to the hot spots. It may also result in a "prune skin" surface on the casting, consisting of overlapping layers of metal coated with an oxide film. A fast pour is almost always provided for to promote uniform section castings. Care must be taken, however, that the metal entering the mold cavity does not cascade excessively over cores or ledges in the mold cavity because this promotes dross formation.

The pouring rate is selected from a chart (Fig. 1) which gives the cross-sectional ingate area needed for any given weight casting, depending on what pouring rate is selected. The author's company chokes at the ingates, using a downsprue to runner bar to ingate ratio of 10:9:8.

Flow-offs are provided for riserless castings to help assure uniformity of metal temperature within the mold. The flow-offs should be small enough that they will freeze before the expansion of mold walls and cores begins. If this is not done, liquid metal will be purged through the flow-offs. This will nullify the rigid mold wall advantage of the dry sand mold.

Sometimes a similar "blossoming" effect can be seen in the pouring basin after the casting is poured. This can be corrected by using two small downsprues instead of one big one.

CASTINGS REQUIRING RISERS

Risers are provided on a casting where any of these conditions exist:

1) A heavy section is adjoined by considerably lighter sections.
2) Two or more metal sections form a junction, and consequently a hot spot. The riser is placed as close to the hot spot as possible.
3) The casting section tapers markedly. The riser is placed at the heavy end.
4) A thin core is surrounded by heavy metal sections. The thin core section once it is heated retains heat much longer than the surrounding metal. It also admits atmospheric pressure into the area. The result is often a porous section in the casting which leaks on test.

Experience has shown that if hot spots cannot be avoided, feed metal must be provided. If possible, the metal should enter the mold through the riser or risers to assure that the hottest metal will be in the riser when pouring is finished. The riser must have an effective section greater than that of the casting section it is feeding. Care must be taken to prevent the riser neck from freezing off before feeding is complete.

For designing blind risers the author's company uses the ratios shown in Fig. 2. Open side risers are constructed in a similar manner. No set design is used for top risers.

When economic considerations do not prevent it, the first casting is made without risers. This casting is cut up and examined for shrinkage. If shrinkage is found, then risers can be placed accurately.

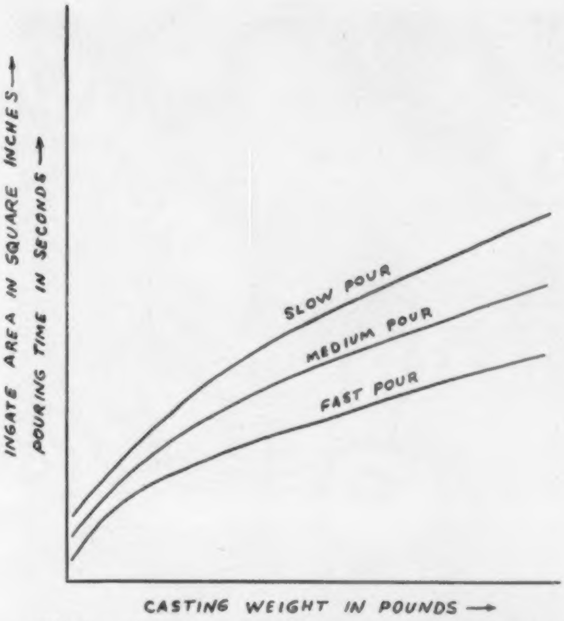


Fig. 1 — Chart for determining cross-sectional ingate area.

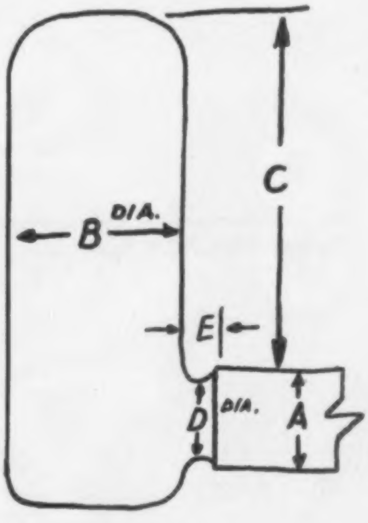
CHILLS, CHEMICAL CONTROL AND DROSS

Chills are used only 1) where a dispersed porous area tends to occur, as in a fillet where a heavy flange meets a thin wall, or 2) where an internal hot spot cannot be reached with a riser. It has been found that a delicate balance of thermal gradients must be achieved. If the chill has too much mass, the porosity will merely be driven to some adjoing area. If it is too small, it will be completely ineffective. If possible, the spot should be fed rather than chilled.

Heats are poured in the range:

T.C., %	3.50-3.80
Si, %	2.30-2.60
Mn, %	0.30-0.50

Fig. 2 — Side riser dimensions. A = section size: B = A + 2 in.; C = 2B; D = ⅔ A; E = ⅓ A max.



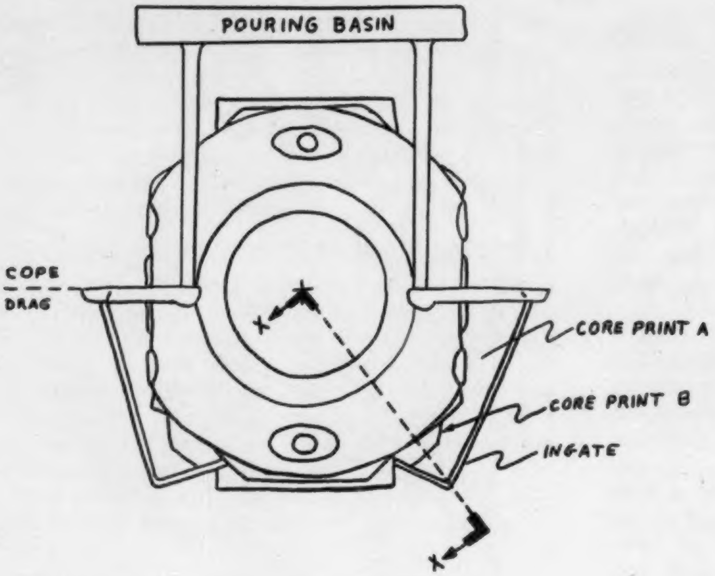


Fig. 3 — Compressor cylinder body.

P, %	0.06-0.09
Mg, %	0.05-0.075

A large variety of castings are regularly produced in this range with sections from ¼ to 18 in. Although the range is rather wide, mold conditions (rigidity, etc.) apparently control solidity more than any combination of chemicals in this range.

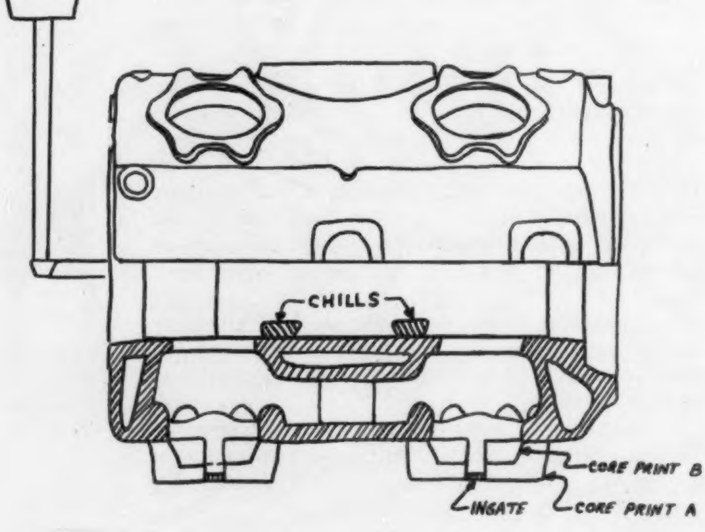
Dross is minimized by these practices:

1) Gate into the bottom of the mold if this will not interfere with risering requirements.
2) Avoid splashing the metal over ledges, against the the edges of cores or spewing it out of narrowing ingate orifices.
3) Keep the metal circulating under overhanging cores or in pockets, but not violently. Dross is not as likely to be trapped if the metal is circulating.
4) Pour fast, but quietly.
5) Place a small package of cryolite in the pouring basin before pouring. The pouring basin is kept full throughout the pouring operation.

Following are some examples to illustrate various gating and risering methods used to produce sound castings.

The compressor cylinder body, shown in Fig. 3 and Fig. 3a had a casting weight of 3,120 lb, pouring weight of 4,000 lb, fast pour and casting section was 2 in. max – ½-in. min. The metal is poured into the bottom of the mold cavity in two stages. First, it enters the runner bar at the joint, and then is carried under gate cores (core prints *A*) and the pocket cores (core prints *B*) into the mold. Chills are rammed up in the barrel core adjacent to the

Fig. 3a — Section X — X of compressor cylinder body shown in Fig. 3.



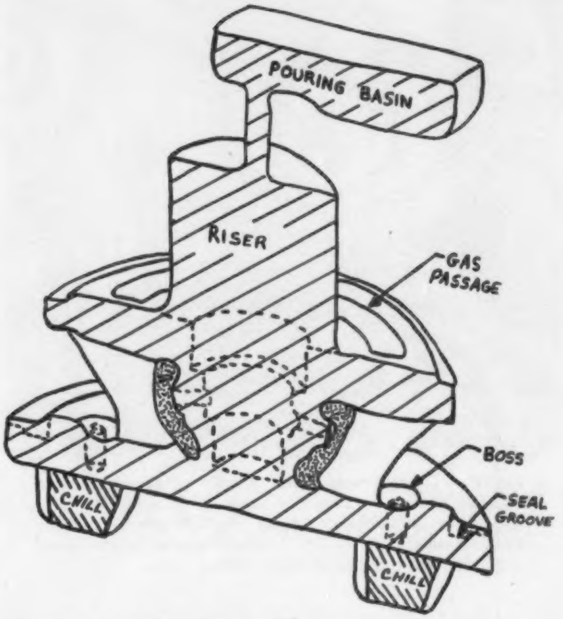
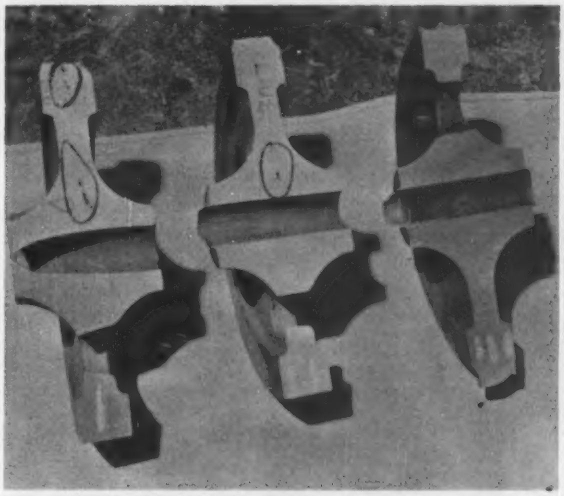


Fig. 4 — Turbine inlet casing — half section.

edges of the thin water jacket core section. These are spots where porosity occurred before chills were used.

The considerable size of the casting, the mass of the cores and scattered thin sections call for a fast, quiet pour. This casting is not risered.

Figure 4 shows a turbine inlet casing, which has a casting weight of 130 lb, a pouring weight of 300 lb, fast pour and a casting section max. 1½-in – ⅜-in. min. This casting has three heavy sections, consisting of the top and bottom faces and the bore. The gas passage walls are predominately thin (⅜-in. section thickness). The exterior surfaces of the gas passages are water cooled and the bore must hold oil The machined casting has several circles of blind bolt holes. The casting must be completely sound throughout.



Figs. 6a and 6b — Gear blank, weight 22 lb. Intake gate ⅞ x 1⅛ in. Bob — 3 in. diameter x 6 in. high (height taken from bottom of intake). In Fig. 6a — No. 1 (left) — dead bob, shrink in gate and hub; no. 2 (center) — live bob, shrink in hub; no. 3 (right) — live bob same size as nos. 1 and 2, but pouring speed reduced by decreasing the choke area from 0.62 sq in. to 0.31 sq in.

The top face and bore are fed by the top riser. The bottom face is chilled by the use of 8 cupcake size chills and 8 smaller chills between the large ones. The thin gas passage walls tended to feed from the

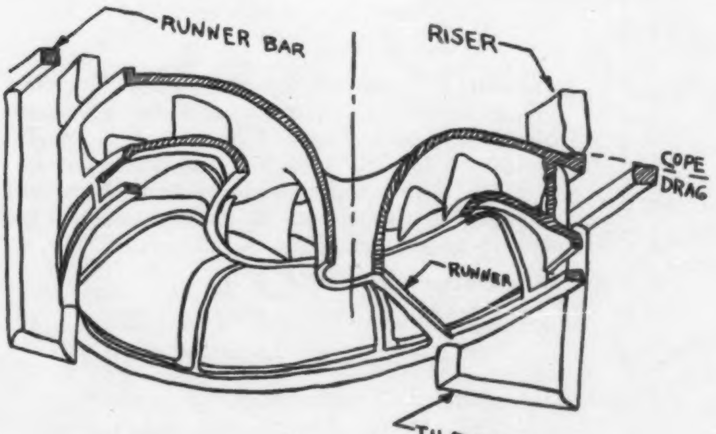


Fig. 5 — Compressor inlet scoop — half section.

heavier sections and cause leakers before this somewhat expensive method was adopted. The dotted lines indicate some of the machined contours of the finished casting.

Figure 5 shows a compressor inlet scoop with a casting weight of 1220 lb, a pouring weight of 2000 lb, fast pour and a casting section of max. 2 in. – min. 5/16-in. This casting has a considerable variation in section thickness because of the vanes, some being quite thin while others flare out to about 2 in. Notice that iron enters the bottom ring through tile gates. Parts of the first metal in flows through a runner into the funnel-shaped section; otherwise it

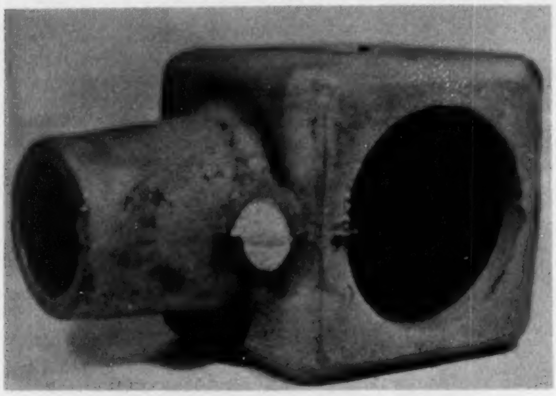


Fig. 7 — Ductile iron. Bob — 2½-in. diameter x 5 in. Gate ⅞ x 1¼-in. Casting weight, 17¾-lb.

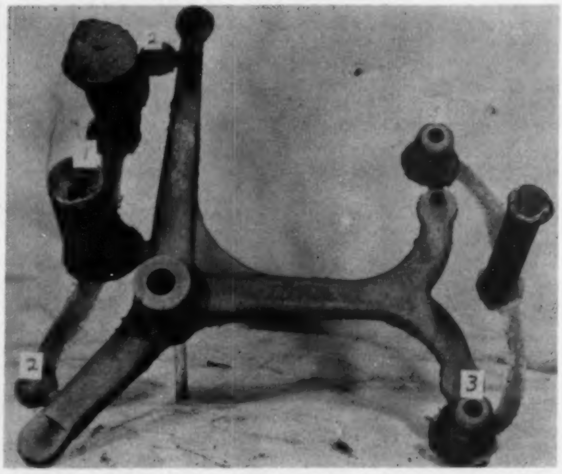


Fig. 8 — Ductile iron. No. 1 = 2½ diameter x 5½. Gate ⅞ x one in. No. 2 — gates ⅞ x ½-in. No. 3 — bobs 2 in. diameter x 2½-in. high. Gates ⅝ x ⅜-in. Casting weight 20 lb. No. 3 intake and bobs are bleeders only. No. 2 gates to heat section only.

would have to rise and cascade down from the top, causing cold laps.

The risers are placed on the top flange directly over the thick ends of the vanes. In this case, it was not practical to gate into the risers because of turbulence. Pouring rate must be fast because of the large mold and core mass, and the great distance the metal must flow.

SHELL MOLDED DUCTILE IRON CASTINGS GATING AND RISERING FOR VERTICAL POURING

by H. O. Meriwether

GATING SYSTEM DESIGN STEPS

1. Select the desired pouring time.
2. Calculate effective sprue height (E. S. H.).
3. Calculate area of choke needed.
4. Calculate runner size required.
5. Calculate runner gate size.
6. Calculate total ingate area.
7. Calculate riser and riser connection sizes.

Pouring Time

The desired pouring time is calculated from the formula:

$$\text{Pouring time} = K_1 \times \sqrt{\text{casting weight}}$$

where K_1 is a constant dependent upon the section size of the casting. The value of K_1 in the author's company's shop for ⅜ to 1 in. sections is 1.8. For thinner sections $K_1 = 1.4$, and for heavier sections $K_1 = 2.0$. These constants have been arrived at through a thorough study of the low loss jobs and seem to be satisfactory.

Effective Sprue Height (E. S. H.)

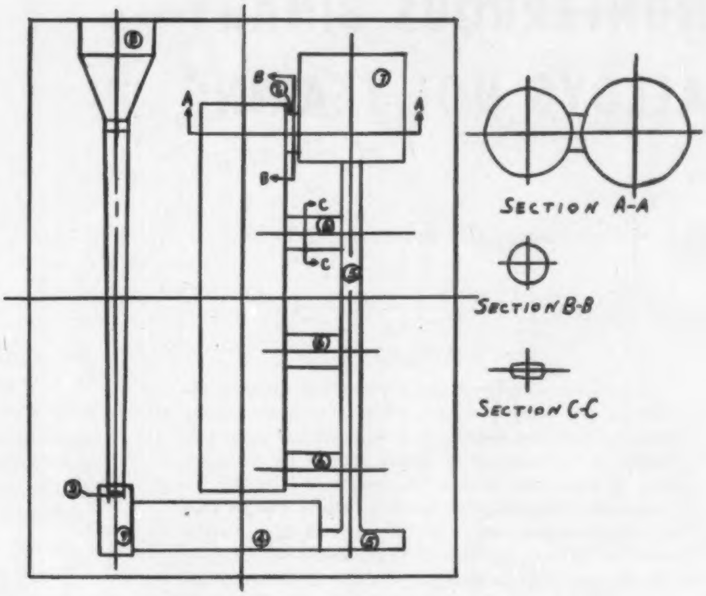
The E. S. H. is calculated from the formula:

$$\text{Effective Sprue Height} = H - \frac{P^2}{2C}$$

where:

H = Height of metal above choke.
C = Height of casting.
P = Height of casting above choke.

H. O. MERIWETHER is Fdy. Methods Supvr., Lynchburg Foundry Co., Lynchburg, Va.



Typical shell mold gating.

Choke Area Calculation

The formula for the calculation of the area of choke is:

$$\text{Area of choke} = \frac{K_2 \times \text{Pouring Weight}}{\text{Pouring time} \times \sqrt{\text{E.S.H.}}}$$

where K_2 is a constant determined experimentally in the company's foundry to be 0.20. This constant compensates for the fluidity of the iron, the frictional loss through the gating system and the force of gravity.

Runner Size Calculation

The calculation of the runner size is done in two steps. First the pouring rate has to be figured, and this is done by the formula:

$$\text{Pouring Rate} = \frac{\text{Area Choke} \sqrt{\text{Effective Sprue Height}}}{K_2}$$

Where $K_2 = 0.20$ (Same as in 3.)

Using this pouring rate and a desired velocity in the runner for slag clean up of 8 in./sec, the desired runner area is calculated by the formula:

$$\text{Runner Area} = \frac{\text{Pouring Rate}}{0.245 \times \text{Velocity (8 in. sec)}}$$

Where 0.245 lb/cu in. = density of molten ductile iron.

Runner Gate Area Calculation

The runner gate is calculated from the equation: Runner Gate Area = 2 × area choke

Total Ingate Size Calculation

The ingate area is calculated from the equation: Ingate area = 2 × Area Choke

Riser and Riser Connection Sizes Calculation

The riser sizes, position and connections are a combination of calculations and experience. The riser is calculated to have a greater cooling factor than the section it is designed to feed plus a safety factor. It is important to keep the connection large enough and close enough to the casting to stay open until after the riser has fed the casting. The formulas used for calculation of riser size is:

$$\text{Riser Diameter} = \frac{\text{Volume}}{\text{Area}} \text{ Casting Section} \times 5$$

Riser connections are found from the formula:

$$\text{Riser connection (Dia)} = \frac{\text{Diameter of Riser}}{4} + \tfrac{1}{2} \text{ in.}$$

Typical Shell Mold Job Calculations

1) $\text{P.T.} = K_1 \times \sqrt{\text{C.W.}} = 2.2\sqrt{64} = 17.6 \text{ sec}$

2) $\text{E.S.H.} = H - \frac{P^2}{2C} = 23 - \frac{20^2}{2 \times 20} = 13$

3) $\text{A.C.} = \frac{K_2 \times \text{C.W.}}{\text{P.T.} \times \sqrt{\text{E.S.H.}}} = \frac{34 \times 64}{17 \times \sqrt{13}} =$

0.36 use $\frac{11}{16}\,\phi = 0.371$

4) $\text{P.R.} = \frac{\text{A.C.} \times \sqrt{\text{E.S.H.}}}{K_2} = \frac{0.371\sqrt{13}}{34} = 3.9 \text{ lb/sec}$

$\text{R.A.} = \frac{\text{P.R.}}{0.245 \times \text{Vel}} = \frac{3.9}{0.245 \times 8} =$

2. use $2\tfrac{1}{4}$ w × $\tfrac{1}{2}$ h Both Sides = 2.16

5) R.G.A. = A.C. × 2 = 0.371 × 2 =
0.742 use $\tfrac{7}{8}$ w × $\tfrac{1}{2}$ h Both Sides = 0.786

6) I.A. = A.C. × 2 = 0.371 × 2 =
0.742 use $1\tfrac{1}{2}$ w × $\tfrac{1}{4}$ h Both Sides = 0.730

7) $\text{Riser} = \frac{V}{A} \times 5$ "$\frac{V}{A}$ of long bar" $= \frac{D}{4} = \frac{4}{4} \times 5 = 5\,\phi$

7) $\text{Riser Conn} = \frac{\text{D of Riser}}{4} + \tfrac{1}{2} = 1\tfrac{3}{4}\,\phi$

8) Pouring Basin = For P.R. of $3\tfrac{1}{2}$ lb/sec to 6 lb/sec use $3\tfrac{1}{2}\,\phi$

9) Sprue Basin = 2 times runner height or minimum of $1\tfrac{1}{2}\,\phi$

NONFERROUS BINARY ALLOYS HOT TEARING

by R. A. Rosenberg, M. C. Flemings and H. F. Taylor

ABSTRACT

A test was developed and adapted for studying the relative hot tearing tendencies of nonferrous alloys. Resistance to hot tearing was rated as the maximum length of test casting in inches that could be made free of tears (the greater the length, the greater the resistance of the metal to tearing). Alloys studied were aluminum-magnesium (0 to 12 per cent Mg), aluminum-tin (0 to 10 per cent Sn), aluminum-copper (0 to 15 per cent Cu), magnesium-aluminum (0 to 20 per cent Al) and magnesium-zinc (0 to 10 per cent Zn).

It was concluded that small amounts of alloying elements lower the resistance of otherwise pure metals to hot tearing by formation of "pockets" or "films" which remain liquid as much as several hundred degrees below the freezing temperatures of the pure metal. These liquid regions lower strength and ductility of the solidifying metal. Various alloying elements affect hot tearing in different ways, due in part to the shape of the resultant films or pockets. When enough alloying element is added to a pure metal so that eutectic is present in amounts greater than that necessary to completely surround the primary grains with a thin film, resistance to hot tearing increases due to improved feeding on a micro-scale.

INTRODUCTION AND LITERATURE SURVEY

When a casting solidifies and cools in a sand mold, it undergoes a certain amount of solid state contraction. If this contraction is hindered by the mold or cores, or by disparate sections designed into the casting, partial or complete rupture of a segment of the casting may occur during solidification and cooling. Under certain conditions rupture can take place at relatively low temperatures (near room temperature); however, fractures usually occur at much higher temperatures (near the solidus of the alloy) and are termed "hot tears." Today, most investigators are in agreement that hot tearing occurs before solidification is complete; this applies for ferrous[1-4] and nonferrous alloys.[1,5-10]

Veroe[5] was the first investigator to study hot tearing as a function of alloy content in aluminum binary systems. He measured average crack length in "U" shaped, permanent mold test castings. In studying aluminum silicon alloys, he showed that the severity of hot tearing increased as the silicon content was raised to 1.90 per cent. Tearing rapidly decreased when silicon was added in larger amounts. Veroe calculated that in alloys containing more than about 12 per cent liquid during the critical stage of solidification, cracks caused by hindered contraction would be filled by liquid so that hot tearing would not occur.

Later studies[6,11] confirmed that hot tearing decreased with increasing eutectic content (above a certain minimum amount); these studies also indicated that hot tearing decreased with 1) decreasing grain size and 2) increasing gas content.

Singer et al[7] conducted elevated temperature tensile tests on several aluminum-silicon alloys, and found the alloys possessed finite strengths but no ductility at temperatures well above the solidus. The temperatures at which the alloys no longer showed finite tensile strengths were taken as the upper limits of a "hot shortness range"; lower limits were the

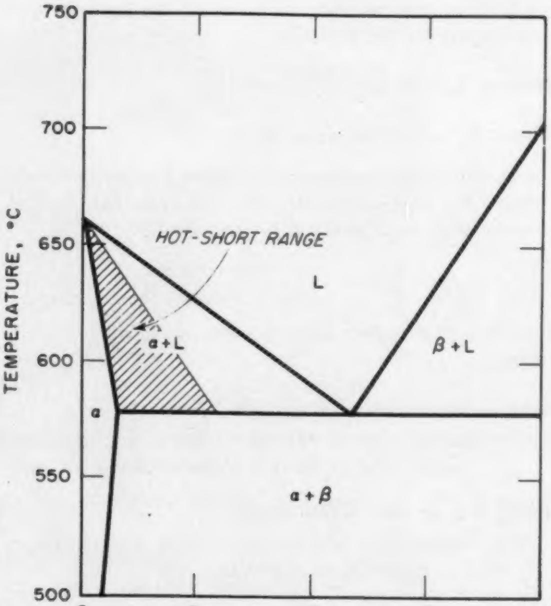


Fig. 1 — Range of hot shortness for aluminum-silicon system.

R. A. ROSENBERG is Consultant, Fdy. Engrg., Walworth Co., Braintree, Mass. M. C. FLEMINGS is Asst. Prof. and H. F. TAYLOR is Prof., Massachusetts Institute of Technology, Cambridge.

(This paper is based on a thesis submitted by R. A. Rosenberg in partial fulfillment for the degree of Doctor of Science to Massachusetts Institute of Technology.)

60-105

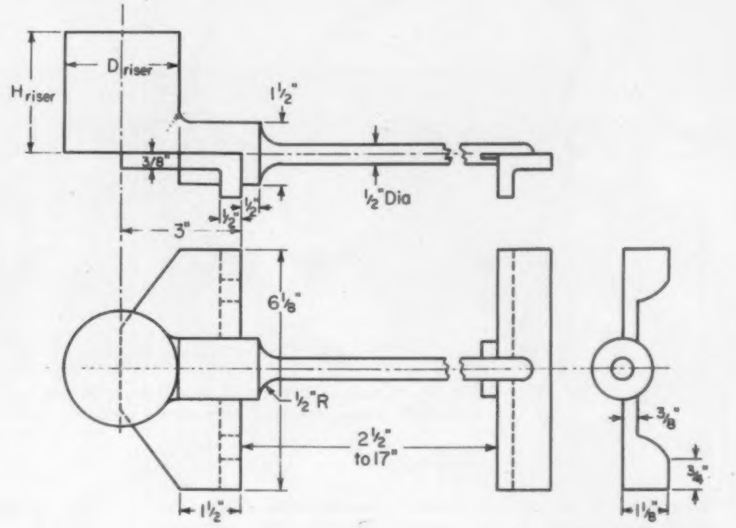


Fig. 2 — Plan view of test pattern.

solidus temperatures (Fig. 1). Alloys with a large hot shortness range should be more prone to hot tearing than others.

Bishop et al[1] concluded that hot tearing resulted from contraction during the late stages of solidification. Working with aluminum-copper and aluminum-silicon alloys (as well as steel) they concluded that tearing takes place during a "film stage" of solidification (when about 10 per cent liquid remains near the surface of the casting).

Magnesium Alloy Hot Tearing

Other investigators have felt that hot tearing in magnesium alloys is also a function of a hot shortness range.[9,10] Spektorova and Lebedeva[9] found no tears in compositions near the eutectic; they also noted that fine grains decreased the range of hot shortness, and therefore should decrease tearing resistance.

Recently, Dodd studied tearing in magnesium-aluminum and magnesium-zinc alloys using a ring type test.[10] He showed that magnesium alloys are not as susceptible to tearing as constitutionally similar aluminum alloys. Gamber[12] developed a hot tear test of the "U" type for both magnesium and aluminum alloys, which is reported to be superior to the various ring type tests.

Fig. 3 — Series of test castings of aluminum-6 per cent tin (grain refined). The longer casting tore completely at the cylindrical section change; tears were observed externally at the critical area of the middle casting; no tears were observed on the smaller test casting.

In the investigation reported herein, studies were conducted of 1) the relative hot tearing tendency of a number of binary alloys and 2) tearing temperatures of several alloys. Metallographic, chemical and microradiographic techniques were employed to assist in developing a better understanding of the fundamental mechanism of hot tearing. A discussion is presented of the fundamental aspects of hot tearing which agrees in many details with theories proposed earlier. However, this discussion delineates clearly 1) the important role of feeding (on a micro-scale) in determining hot tearing characteristics and 2) the role of shape and distribution of low melting segregates in determining hot tearing characteristics.

EXPERIMENTAL INVESTIGATION

Melting, Molding, Test Pattern

The test adopted for hot tearing in this work was essentially one developed during previous studies at M.I.T.[2,13] The test pattern consisted of a long, thin cylinder joined to a heavier cylindrical section; the ends of the test pattern were restrained by flanges. Lengths of the thin cylindrical bars were increased or decreased in a test series so as to vary severity of hot tearing (Figs. 2, 3), and the hot tearing tendency of each alloy was rated as the maximum length test casting that could be made free of tears.

If a test casting was not visibly torn, a section was cut from the area susceptible to tearing, polished, etched and examined (Fig. 4). Castings were considered free of tears if none were visible when the section was examined at 10 × magnification.

Tearing was studied in the binary systems aluminum-magnesium, aluminum-tin, aluminum-copper, magnesium-aluminum and magnesium-zinc. Aluminum-tin alloys were grain refined by addition of 0.18 per cent titanium to each melt; aluminum-magnesium

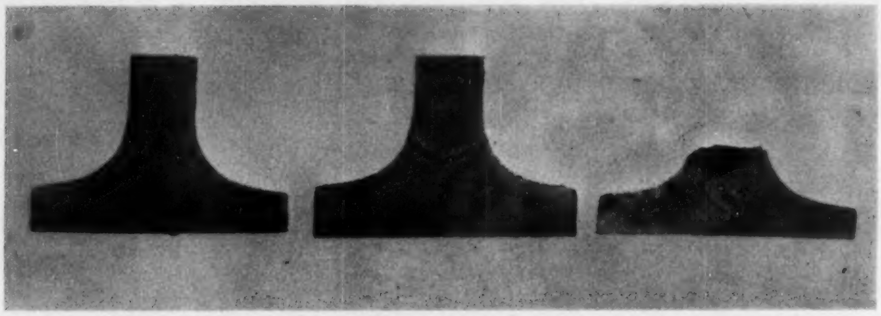


Fig. 4 — Critical sections of aluminum-2.90 per cent copper (grain refined). ***Left*** **— no tears; center — tear across section;** ***right*** **— completely torn section.**

alloys were not grain refined; aluminum-copper alloys were tested in the grain refined and non-grain refined conditions. The charge materials used in the aluminum heats, depending on the alloy studied, consisted of aluminum (99.90 per cent), high purity tin, magnesium (99.98 per cent), aluminum-copper master alloy (50 per cent Cu) and aluminum-titanium master alloy (5 per cent Ti) for grain refinement of aluminum alloys. Magnesium heats, depending on the alloy tested, were made from magnesium (99.98 per cent, aluminum (99.99 per cent) and high purity zinc.

All alloys were melted in 30 lb heats by standard, carefully controlled procedures. Aluminum heats were melted in graphite crucibles in a gas-fired furnace. The aluminum-magnesium and aluminum-copper alloys were degassed in the furnace with dry nitrogen at 1350-1400 F; aluminum-tin alloys were degassed with chlorine at the same temperature. Pouring temperatures were 120-130 F above the liquidus.

Magnesium alloys were melted in steel crucibles placed in a gas-fired furnace. A proprietary flux was used to minimize burning, and degassing was by means of a solid degasser which contained chlorine.

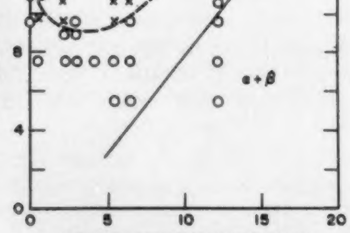


Fig. 5 — Hot tearing characteristics of aluminum-magnesium alloys superimposed on portion of phase diagram.

The solid degasser was plunged into the crucible at 1400 F and held until completely volatilized; this treatment resulted in grain refinement of the magnesium-aluminum alloys, as well as degassing of the alloys. Pouring temperatures for all alloys were 120-130 F above the liquidus.

Several molds were prepared for each alloy tested; the molds differed from one another only in the length of the restraining sections (Fig. 2). Mold hardness for all castings was kept as close as possible to number 50. Composition of the sand mixture for the aluminum castings was:

No. 140 Sand, lb	100.00
Southern bentonite, lb	5.00
Cereal, lb	0.75
Water, lb	3.50

Composition of the sand mixture for the magnesium castings was:

No. 80 sand, lb	100.00
Southern bentonite, lb	4.50
Boric Acid, lb	1.50
Sulfur, lb	1.50
Diethylene glycol, lb	1.50
Water, lb	3.00

Hot Tearing Ratings

Results of hot tearing experiments on the various alloys studied are given in Figs. 5-9. For each alloy system, the curve relating hot tear resistance to composition is superimposed on the appropriate phase diagram. Crosses refer to test castings which were torn; triangles represent test castings which showed no tears after careful examination.

Both pure aluminum and pure magnesium tore when the length of the restraining bar was approximately 12 in.; addition of small amounts of solute to the pure metals decreased resistance to tearing. Some alloys decreased this much more drastically than others; for example, when ½-per cent of tin was added to aluminum, resistance to tearing was reduced by a factor of 3; however, a similar amount of copper had only a relatively small effect on tearing.

Minimum tear resistance for the aluminum-magnesium alloys studied was 9 in. (at 4-6 per cent Mg); for the aluminum-copper alloys it was 3½-in. (at

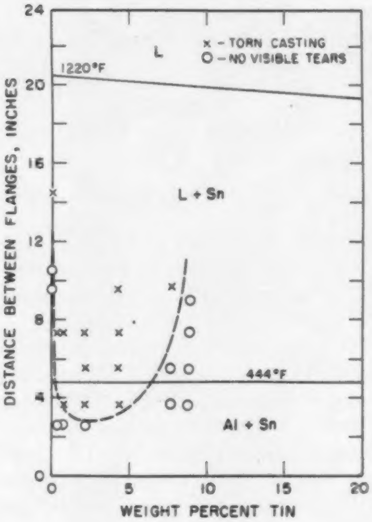


Fig. 6 — Hot tearing characteristics of aluminum-tin alloys superimposed on portion of phase diagram.

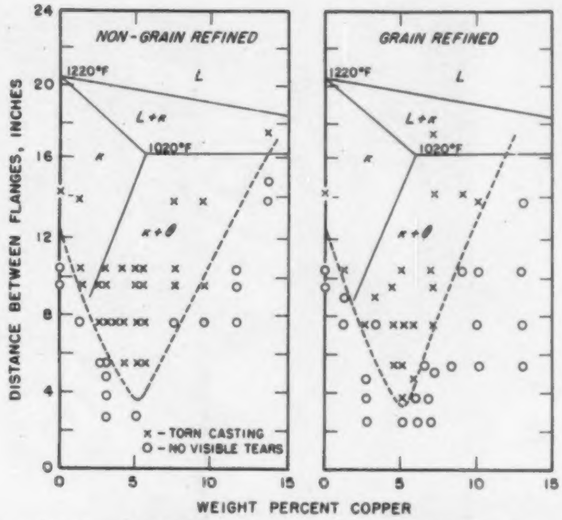


Fig. 7 — Hot tearing characteristics of nongrain refined and grain refined aluminum-copper alloys superimposed on portion of phase diagram.

5 per cent Cu), and for the aluminum-tin alloys it was less than 3 in. (at 0.25-5 per cent Sn). Minimum tear resistance for the magnesium-aluminum alloys was 7 in. (at 4 per cent Al), and for the magnesium-zinc alloys it was 5½-in. (at 5 per cent Zn).

In all alloys studied, tear resistance was a minimum at one or more compositions in the range of ¼ to 10 per cent alloy additions; addition of larger amounts of solute increased resistance to tearing. Results of this study agree qualitatively with those of previous investigators, although in most cases hot tearing curves are shifted somewhat to the right of those obtained earlier.[10,11] This is perhaps due to better feeding of castings tested in the work reported herein. Surprisingly, grain refining was found to have no effect on hot tearing with the experimental methods employed. Fig. 7 compares tearing characteristics for grain refined and non-grain refined aluminum-copper alloys; within experimental error, the curves are identical.

HOT TEARING TEMPERATURE DETERMINATION

Test Procedure

Although much research has already been done to measure temperatures at which hot tearing occurs[2,14,15,16,17] a portion of this investigation was directed toward this end, with the particular aim to obtain an accurate measurement of the amount of solid present in nonferrous alloys when tearing occurs. The test method developed and used was to observe the solidification of a test casting through a vycor glass window; the time at which tearing first became visible was recorded and related to the temperature of the casting at that time.

The test pattern employed was similar to that used for measuring hot tearing in the first part of this study, except that it had a square (rather than

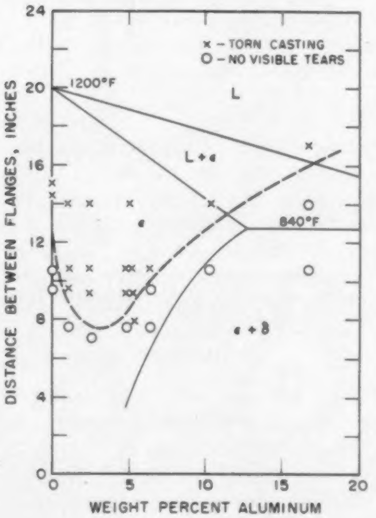


Fig. 8 — Hot tearing characteristics of magnesium-aluminum alloys superimposed on portion of phase diagram.

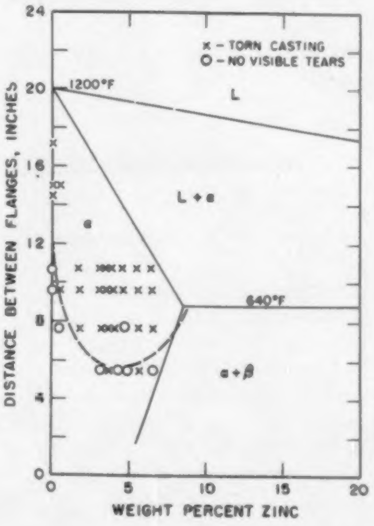


Fig. 9 — Hot tearing characteristics of magnesium-zinc alloys superimposed on portion of phase diagram.

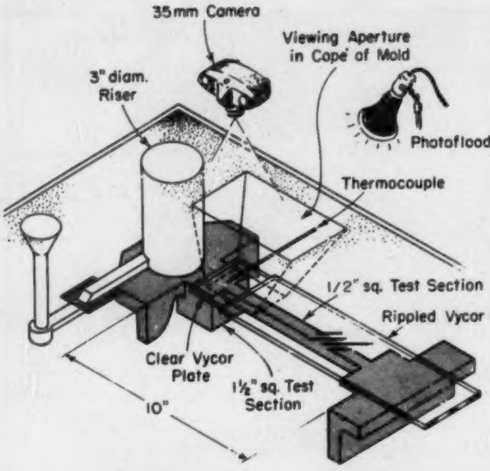


Fig. 10 — Mold setup for observing hot tearing in aluminum-tin alloys.

round) cross-section (Fig. 10). The pattern was molded in sand and a clear vycor glass "window" was placed over the section likely to tear. A vycor plate was also placed over the remainder of the cope side of the test casting to equalize cooling conditions on this face. A chromel-alumel thermocouple was placed in the mold cavity ¼-in. behind the region of change in cross-section and about ¼-in. below the parting line; the thermocouple was connected to a continuous recorder.

Sand over the glass window was removed before pouring. When metal was poured into the mold a continuous cooling curve was obtained, and solidification of the casting could be observed through the glass plate in the vicinity of the abrupt change of cross-section. Thus, the formation of hot tears was visually (or photographically) observed, and the time of tearing correlated with the thermocouple data being obtained.

The apparatus described above was used to measure hot tearing temperatures of aluminum alloys containing from 0.5 to 4 per cent tin. These alloys were chosen because:

1) Aluminum-tin alloys containing less than about 4 per cent tin have low resistance to hot tearing (Fig. 6).
2) Aluminum has almost no solubility for tin. As a result, the per cent solid existing at a given temperature can be calculated with greater accuracy than if solubility were higher (Appendix).
3) Near the end of solidification, a large drop in temperature results in little freezing. For example, in an aluminum 1 per cent tin alloy, 90 per cent of the freezing occurs within 22 F of the liquidus, and the next 9 per cent solidifies over a range of 752 F; the last 1 per cent freezes as eutectic (Fig. 11). When calculations of per cent solid are made in the region of 90-99 per cent solid, these calculations can be made with a high degree of accuracy. Small variations in temperature from center to surface of a casting are unimportant.

As an example, when the center of an aluminum-1 per cent tin test casting is 1150 F it is approximately 97 per cent solid. If the surface of the casting were as much as 40 F lower than the center it would still only be 98 per cent solid; the casting surface would have to be 706 F lower than the center for it to be 99 per cent solid. Actually, only shallow temperature gradients are present in these alloys, and during freezing the surface temperature is not far from that of the center.

Tearing Temperature

Figure 12 shows a sequence of photographs taken during solidification of an aluminum-1 per cent tin alloy in the test apparatus. Initial tearing began at 1120 F; at this temperature the alloy is 98 per cent solid (Fig. 11). Actual temperaure measurement for this calculation was in the center portion of the casting; however, the surface must also be nearly 98 per cent solid for the reasons discussed above.

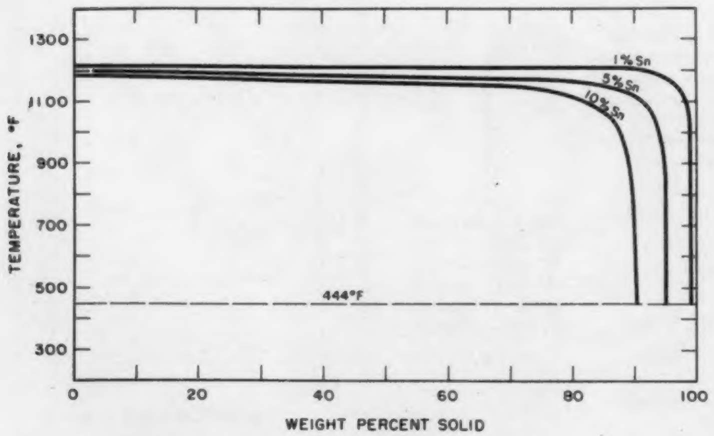


Fig. 11 — Temperature vs. weight per cent solid for aluminum-tin alloys calculated from equation (3) of Appendix.

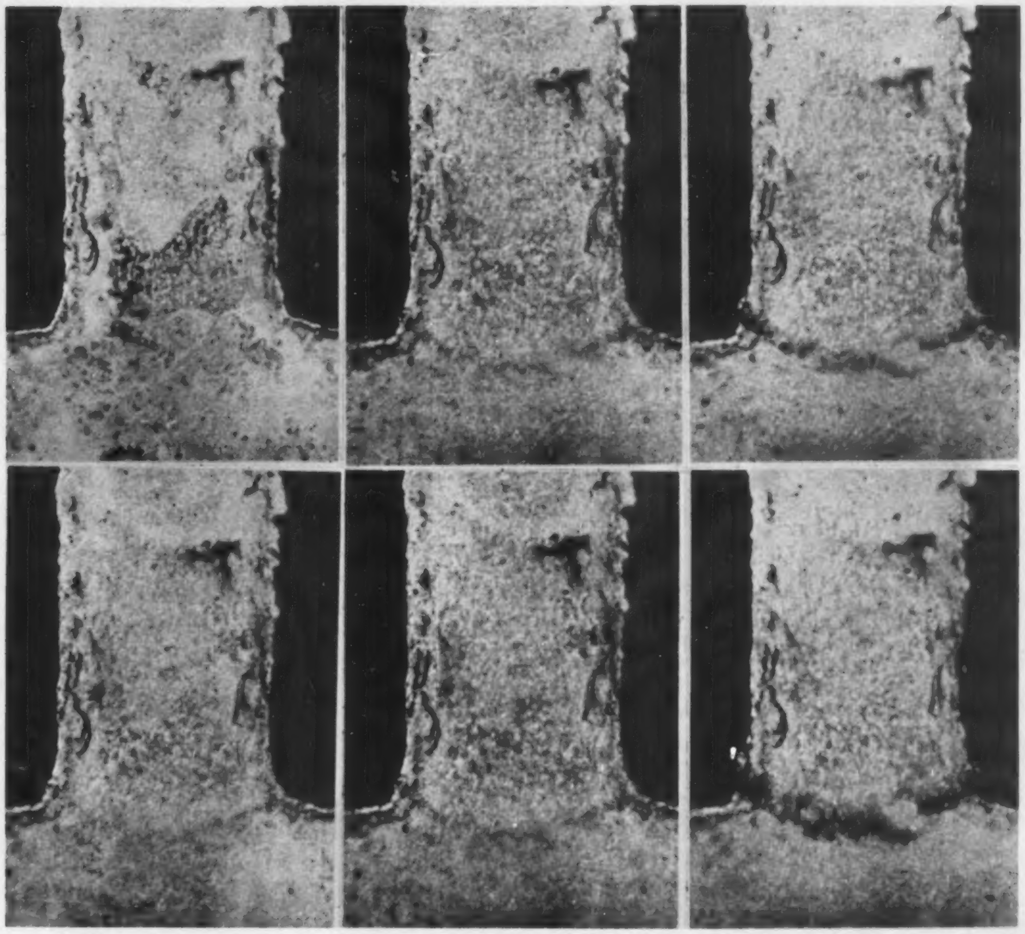


Fig. 12 — Series of enlarged photographs showing initiation (at 1120 F), and subsequent propagation, of hot tears in critical area of a test casting of aluminum-1.0 per cent tin. *Left* — top — 1243 F, bottom — 1120 F; *center* — top — 1053 F, bottom — 1025 F; *right* — top — 897 F, bottom — 560 F.

A number of test castings were poured to measure effects of casting length, tin content and pouring temperature on temperature of hot tearing. In all cases, tearing was found to begin at between about 95 and 98 per cent solid (Fig. 13). Increasing the pouring temperature appeared to increase temperature of tearing slightly, but it would be necessary to pour more castings to confirm this observation.

HOT TEARING MECHANISM

In agreement with previous studies,[1-10] this investigation has shown that hot tearing occurs late in the solidification process. At some time near the end of solidification, thinner sections of a casting become "coherent" (acquire measurable tensile strength) and begin to contract. If the molding material is relatively rigid, the contraction stresses are transferred to hotter, weaker locations. At these locations (hot spots) one or more effects will occur:

1) Liquid may flow into the region of the hot spot, preventing formation of open hot tears. This will happen if thermal gradients are steep so that substantial liquid is present in the hot spot during cooling and contraction of the thinner member.
2) The region of the hot spot may gain sufficient strength and/or ductility that open hot tears will not form. This will happen if the hot spot is sufficiently solid (and if solidification mode is favorable) so that it can withstand the applied stress.
3) Intergranular failure (open hot tears) may occur at the hot spot.

Each of the above is described in more detail below.

Liquid Flow

Figure 14 shows the progress of solidification of an aluminum-1 per cent copper alloy in the hot tear casting. The figure is schematic, but is based on actual thermal measurements, and on calculations using equation (2) of the Appendix. After 2 min, the thin section of the casting is completely solid and is contracting; at this time the fillet area (where tearing occurs) is still almost entirely liquid, and liquid can flow readily to compensate for contraction in the thin member.

After 4 min, the fillet portion of the casting is

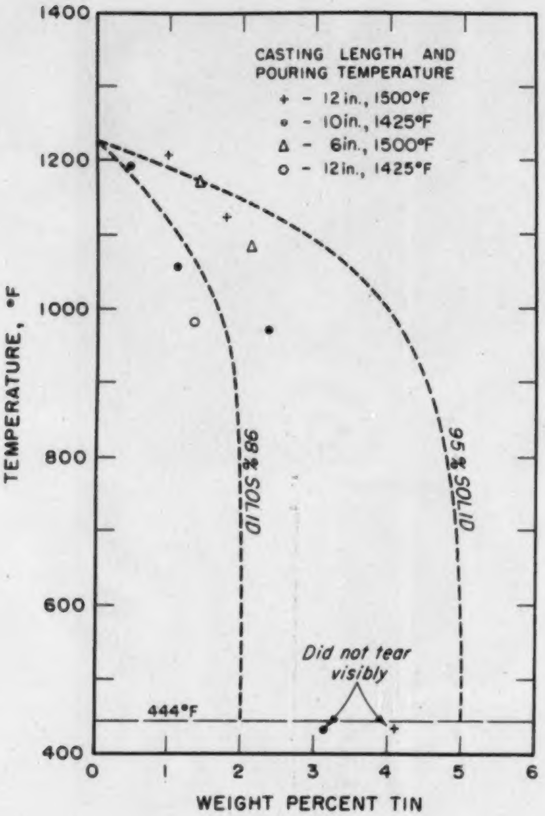


Fig. 13 — Hot tearing temperature vs. weight per cent tin for aluminum-tin alloys of varying length. Cast from 1500 and 1425 F.

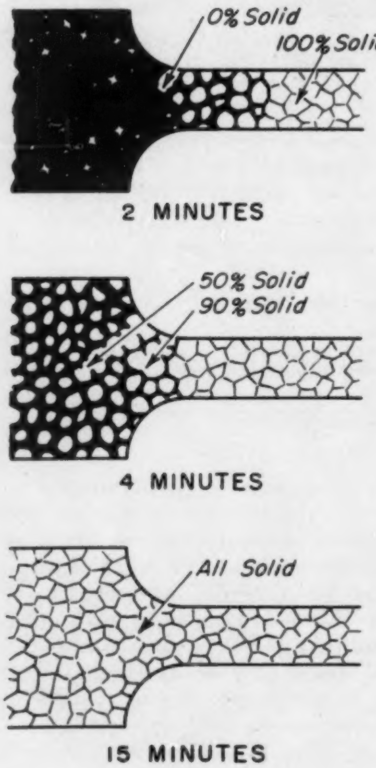


Fig. 14—Schematic of solidification of aluminum-1.10 per cent copper alloy in hot tear test casting. Amount of solid at various times calculated from thermal analysis, using equation (1) of Appendix.

about 90 per cent solid near the thinner section and 50 per cent solid near the heavy section. Liquid can still flow between the grains to compensate for contraction. Solidification of the entire filleted area is complete only after 15 min; during much of this time, feed channels are open in the critical location and liquid flows readily to fill incipient hot tears. If open hot tears are to occur, contraction stresses must be exerted on the critical area late during solidification when liquid can no longer flow.

That liquid does flow to relieve contraction stresses is often evidenced by segregation in regions of castings susceptible to hot tearing. Liquid which feeds shrinkage (or tears) late in the solidification process is relatively rich in solute, and so leads to positive segregation in locations to which it flows. Figure 15 summarizes results obtained in this study on aluminum-1.10 per cent copper hot tear test castings. Movement of liquid late in solidification resulted in increased copper content at or near the fillet area, particularly in castings with long restraining members.

Segregation, such as that described, is usually fairly diffuse and is not observable metallographically or by similar techniques; it is usually not deleterious to service properties of castings. Occasionally, however, the segregation appears in narrow zones which are rich in low melting constituents. Figures 16 and 17 are two examples of this. Sometimes (particularly in certain magnesium alloys) the zones are visible as light or dark streaks on radiographic films. This type

of segregation may or may not be deleterious to properties (depending on degree, location, solution treatment employed, etc.).

In view of the relation between feeding (on a micro-scale) and hot tearing, it is not surprising that alloys which are relatively free of microporosity are usually also less prone to hot tear. Optimum resistance to tearing is obtained in alloys which 1) freeze over a narrow range of temperature and/or 2) possess relatively large amounts of eutectic liquid; these are the alloys usually susceptible to microporosity. Also, foundry techniques which reduced microporosity (improve feeding) almost always reduce or eliminate hot tears; these techniques include improved directional solidification through use of chills, use of insulating or exothermic materials, improved design for feeding, etc.

Solid (or Nearly Solid) Casting Strength and Ductility

Although feeding on a micro-scale is of great importance in determining hot tearing characteristics, other factors may also have an influence. For example, it is difficult to explain, on the basis of feeding alone, why ½ per cent of tin reduces resistance to tearing so much more drastically than does a similar amount (or much larger amount) of copper.

Late in the solidification of sand castings flow of liquid metal is restricted by the narrow interdendritic channels remaining,[18,19] and so the liquid can no longer fill incipient tears. At this point, alloys which will be most resistant to hot tearing will be those that gain strength and ductility rapidly. An example is the excellent resistance to tearing of pure metals, due to their "skin type" freezing; outer portions of castings of a pure metal may be strong

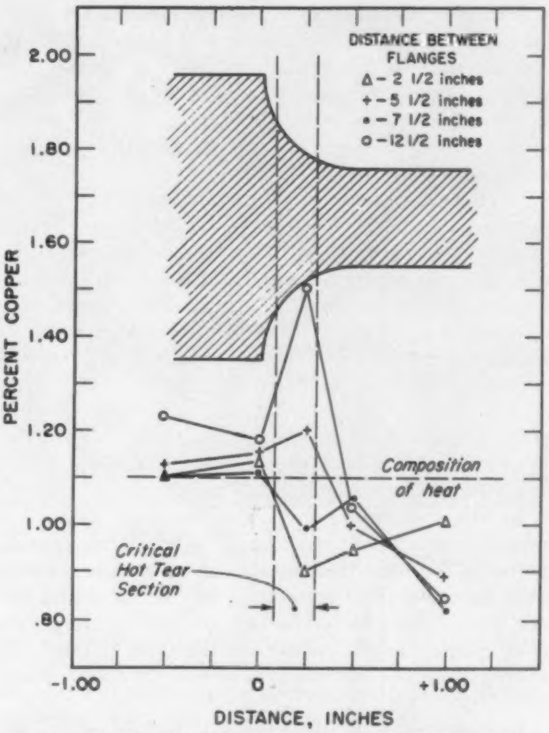


Fig. 15 — Distribution of copper in critical hot tear area in 2½-in., 5½-in., 7½-in. and 12½-in. length castings of aluminum-1.10 per cent copper-0.18 per cent titanium. One-half in. *R* fillet joining 2 in. to ½-in. cylindrical section represented on above diagram from 0 to + ½-in.

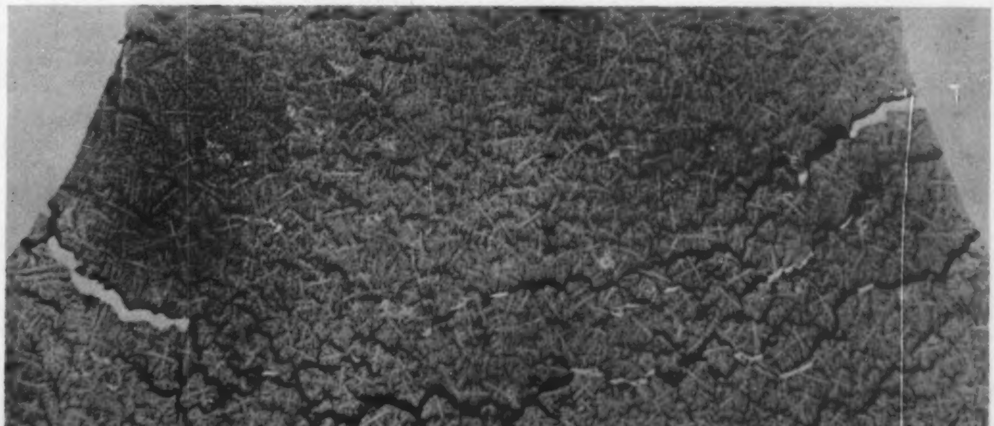


Fig. 16 — Microradiograph of critical area of hot tear test casting. Aluminum-6.6 per cent copper (grain refined); length of restraining section was 7½-in. Dark streaks are segregate; the two white streaks near the surface are fine hot tars. Original magnification approximately 8 ×.

and ductile while central portions are highly fluid. Low alloy steel, free of sulfur and other impurities can behave in somewhat similar fashion.[20] Presumably, binary alloys with a large amount of eutectic should also gain strength rapidly near the end of solidification, because the eutectic freezes at or near a single temperature.

Small amounts of many alloying elements, or impurities reduce the tearing resistance of pure metals by lowering strength and ductility of the semi-solid casting. This occurs because lower melting segregates form at grain boundaries. An extreme example is shown in Fig. 11. As little as ½ per cent tin added to pure aluminum lowers the temperature of final solidification by over 700 F (from 1220 to 444 F). Over 99 per cent of the alloy solidifies near the melting point of pure aluminum, but approximately the last ½ per cent must cool over the 700 F interval before solidifying completely.

In this and similar cases, the last small amount of liquid is nearly all distributed between the primary grains of the solidified metal. The casting is so nearly solid that the small amount of liquid remaining cannot flow to fill incipient hot tears. However, there is sufficient liquid present so that the nearly solid casting possesses extremely low strength and ductility.

Results from this study indicate the shape and distribution of liquid segregates existing in a casting near the end of solidification have an important bearing on hot tearing characteristics (by affecting strength and/or ductility) of the nearly solid casting. The shape and distribution of the liquid segregate is affected by factors such as surface tension, amount of solute, diffusion rates, etc.

Metallographic examination of a large number of test castings showed that 1) minimum resistance to tearing was usually found when just sufficient eutectic was present in the casting microstructure to surround each individual dendrite and 2) there was a marked difference in the amount of alloying element (or of calculated per cent eutectic) required to effect this complete surrounding. For example, in aluminum-copper alloys, the last eutectic liquid tended to separate into small, apparently isolated "pockets"; the eutectic did not visibly surround each grain until about 5 per cent copper (corresponding to 12 per cent eutectic) was present in the alloy (Fig. 18).

Minimum resistance to hot tearing in the aluminum-copper system was observed at about 5 per cent copper; small additions of copper had a relatively small effect on hot tearing. In aluminum-tin alloys different results were obtained. A fine "film" of eutectic appeared to surround each grain when tin was present in amounts less than about 0.5 per cent (corresponding to about 0.5 per cent eutectic). Minimum tearing was observed in this system at about 0.5 per cent tin.

An interesting correlation was observed between as-cast tensile strength and resistance to hot tearing. Figure 19 is a typical example for the magnesium-aluminum system. Similar results were obtained for magnesium-zinc and aluminum-copper alloys. Maximum as-cast tensile strengths in each system were obtained in the alloy with minimum resistance to tearing. This is apparently because in each case the solute produces a relatively brittle eutectic. Increasing amounts of solute increase strength until enough of the brittle constituent is present to completely surround each grain; lower strengths then result with further additions. Thus as-cast tensile strength decreases from a maximum, and resistance to hot tear-

Fig. 17 — Microradiograph of critical area of hot tear test casting. Aluminum-9.96 per cent copper (not grain refined). Length of restraining section was 9½-in. Dark streaks are segregate; light areas are incipient tears of microporosity. Original magnification approximately 8 ×.

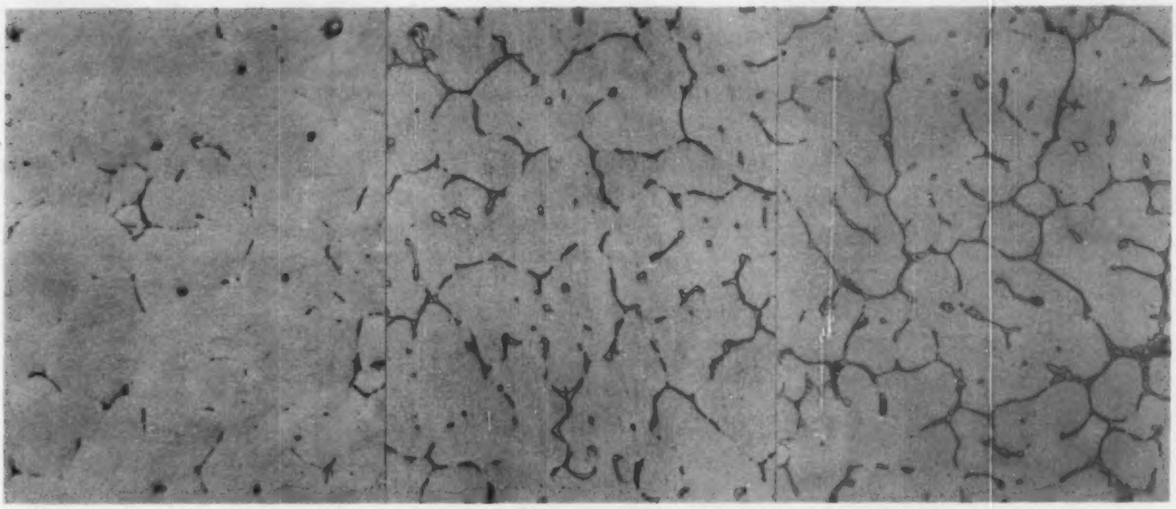


Fig. 18 — Photomicrographs showing distribution of segregate in grain refined aluminum alloys containing 1.96 (*left*), 5.03 (*center*) and 7.25 (*right*) per cent copper. Minimum resistance to tearing is at about 5 per cent copper.

ing is at a minimum, for alloys where each grain is completely surrounded by eutectic.

CONCLUSIONS

A new test was developed for studying relative hot tearing resistance of nonferrous alloys. Alloys studied were aluminum-magnesium (0 to 15 per cent Mg), aluminum-tin (0 to 10 per cent Sn), aluminum copper (0 to 15 per cent Cu), magnesium-aluminum (0 to 20 per cent Al) and magnesium-zinc (0 to 10 per cent Zn).

Hot tearing resistance was rated as the maximum length test casting (in inches) that could be made free of tears—the greater the length, the greater the resistance to tearing. For all alloy systems, resistance to tearing was high for low solute additions, decreased to a minimum and then increased with further additions. Minimum resistance to tearing (measured in inches of sound test bar) for the aluminum-magnesium alloys studied was 9 in. (at 4 to 6 per cent Mg), for the aluminum-copper alloys it was 3½-in. (at 5 per cent Cu) and for the aluminum-tin alloys it was less than 3 in. (at 0.25-5.0 per cent Sn).

Minimum resistance to tearing for the magnesium-aluminum alloys was 7 in. (at 4 per cent Al), and for the magnesium-zinc alloys it was 5½-in. (at 5 per cent Zn). Results of tests conducted on aluminum-copper alloys showed no apparent effect of grain refinement on hot tearing. Experimental evidence and calculations showed test castings of aluminum-tin alloys (0 to 4 per cent Sn) tore when they were approximately 95-98 per cent solid.

Small amounts of alloying elements lower resistance to tearing of pure aluminum and magnesium. This is because the alloys form liquid films or pockets which reduce strength and ductility to the nearly solid casting. Some alloying elements reduce resistance to tearing much more than others. This is due, in part

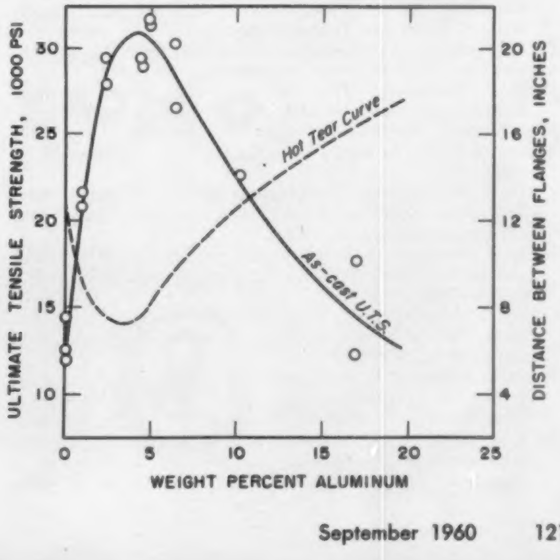


Fig. 19 — As-cast ultimate tensile strength and hot tear characteristics for magnesium aluminum alloys.

at least, to the different shapes of the last liquid areas to freeze.

Minimum resistance to tearing is obtained in a given (eutectic) binary system when just enough eutectic is present to completely surround the primary grains. Solutes in amounts greater than that necessary for the eutectic to completely surround primary grains increases resistance to tearing. This is due to influx of liquid to the areas susceptible to tearing (filling of incipient tears).

ACKNOWLEDGMENT

This investigation was supported by the Air Force through Instrumentation Laboratory, M.I.T. The authors wish also to acknowledge assistance of the foundry staff under supervision of Mr. Edwin Backman, and of Mr. George E. Schmidt who prepared the illustrations.

REFERENCES

1. H. F. Bishop, C. G. Ackerlind and W. S. Pellini, "Investigation of Metallurgical and Mechanical Effects in the Development of Hot Tearing," AFS TRANSACTIONS (1957).
2. I. Minkoff, "Influence of Design on Hot Tearing of Steel Castings," S. M. Thesis, Dept. of Met., M.I.T., (Jan. 1956).
3. K. Beckius, "Metallurgical Aspects on Hot Tearing in Cast Steel," International Foundry Congress, Stockholm, 19-24, VIII (1957).
4. Merton C. Flemings, Harold F. Foley and Howard F. Taylor, "The Effect of Design on Hot Tear Formation," Research Report to Steel Founders' Society of America, (Aug. 1959).
5. J. Veroe, "The Hot Shortness of Aluminum Alloys," *Metal Industry, vol. 48*, p. 431 (1936).
6. D. C. G. Lees, "The Hot Tearing Tendencies of Aluminum Casting Alloys," *J. Inst. of Metals, vol. 72*, p. 343 (1946).
7. A. R. E. Singer and S. A. Cottrell, "Properties of Aluminum-Silicon Alloys at Temperatures in the Region of the Solidus," *J. Inst. of Metals, vol. 73*, p. 33 (1947).
8. A. R. E. Singer and P. H. Jennings, "Hot Shortness of Some Aluminum-Iron-Silicon Alloys of High Purity," *J. Inst. of Metals, vol. 73*, p. 273 (1947).
9. S. I. Spektorova and T. V. Lebedeva, "Determination of Hot Shortness of Aluminum Alloys and Magnesium Alloys," Department of the Secretary of State of Canada, Foreign Languages Div., Bureau of Translation, No. 13561 Russian (BVP) (May 4, 1955).
10. R. A. Dodd, "Hot Tearing of Binary Magnesium-Aluminum and Magnesium-Zinc Alloys," Progress Report No. 2 (Hot Tearing Magnesium Castings); (Aug. 1956).
11. R. A. Dodd, "Hot Tearing of Castings: A Review of the Literature," Research Report No. PM584, Canadian Department of Mines and Technical Surveys (July 15, 1955).
12. E. J. Gamber, "Hot Cracking Test for Light Metal Alloy Castings," AFS TRANSACTIONS, *vol. 67*, p. 237 (1959).
13. R. A. Rosenberg, "Hot Tearing in Magnesium Castings," S. M. Thesis, Dept. of Met., M.I.T. (June 1956).
14. I. Minkoff, "Elements of Design for Prevention of Hot Tearing in Steel Castings," Sc.D. Thesis, Dept. of Met., M.I.T. (Aug. 1957).
15. U. K. Bhattacharya, C. M. Adams and H. F. Taylor, "Stress Required to Hot Tear Plain Carbon Cast Steel," AFS TRANSACTIONS, *vol. 62*, p. 557 (1954).
16. H. F. Bishop, C. G. Ackerlind and W. S. Pellini, "Metallurgy and Mechanics of Hot Tearing," AFS TRANSACTIONS, *vol. 60*, p. 818 (1952).
17. U. K. Bhattacharya, "High Temperature Failure of Cast Steel Due to Hindered Contraction," Sc.D. Thesis, Met. Dept., M.I.T. (1954).
18. M. C. Flemings, H. F. Taylor, "Adapting Theory to Practice in the Manufacture of Light Metal Casting," *Transactions, 25th International Foundry Congress*, Brussels, p. 149 (1958).
19. S. Z. Uram, M. C. Flemings and H. F. Taylor, "Effect of Structure and Microporosity on Mechanical Properties of High Strength Cast Steel," AFS TRANSACTIONS, *vol. 68* (1960).
20. K. Beckius, M. C. Flemings and H. F. Taylor, "A Study of Hot Tearing in Steel Castings," *Transactions, 26th International Foundry Congress*, Madrid (1959).
21. Scheil, "Bemerkungen zur Schichtkristallbildung," *Zeitschrift fur Metallkunde, vol. 34*, p. 70 (1942).

APPENDIX

Per Cent Solid Calculations as Function of Solidifying Nonferrous Castings Temperature

In practice, the assumptions of "complete non-equilibrium" solidification appear to describe fairly well the solidification of many aluminum alloys. These assumptions are 1) no diffusion in the solid state, 2) complete diffusion in the liquid state on a micro-scale and 3) no macrosegregation. Based on these assumptions, the amount of liquid present at any point in a solidifying casting can be expressed as a function of the temperature at that point, and the amount of eutectic present in the final casting can be readily determined.

The method for making the calculations has been outlined by several investigators, including Scheil.[21] For alloy systems where the liquidus and solidus are essentially straight lines, the general expression for the liquid fraction can be written as a function of the liquid composition:

$$f_L = \left(\frac{C_0}{C_L}\right)^{\frac{1}{1-K}} \qquad (1)$$

where:

f_L = fraction liquid.

C_0 = initial solute concentration (per cent).

C_L = solute concentration in liquid when f_L fraction liquid remains (per cent).

K = partition ratio, $\left(K = \frac{C_s}{C_L}\right)$, where C_s = solute concentration in solid when f_L fraction liquid remains.

or it can be written as a function of the temperature at the point in question:

$$f_L = \left(\frac{M_L\ C_0}{T_m - T}\right)^{\frac{1}{1-K}} \qquad (2)$$

where:

M_L = slope of liquidus (F/%, C/%).

T_m = melting point of pure solvent (F, C).

T = temperature when f_L fraction liquid remains (F, C).

For alloys (such as aluminum-tin) where solid solubility is negligible, equation (1) reduces to

$$f_L = \frac{C_0}{C_L} \qquad (3)$$

Equation (3) is valid even for low solidification rates (solid diffusion cannot take place since solid solubility is negligible); also it is valid regardless of curvature of the liquidus lines.

Circle No. 145, Page 147

NEWS and VIEWS

Program for Regional Conventions
AFS Sponsors 10 Research Projects
Apprentice Contest Starts Oct. 1

1961 Convention in San Francisco Spotlights Growth of Far West

How mechanization and modernization can solve many of the industry's problems will be demonstrated next spring at the AFS Castings Congress and Exposition. It will be held May 8-12 in San Francisco. This is the first time for the event on the west coast. The Convention will spotlight the western states' rapid growth in population and industry.

Special emphasis will be placed on solving area problems. Exhibits will be geared to serving needs of the coastal states. The exposition will draw heavily from far west foundry equipment manufacturers and suppliers. In addition, exhibitors will come from all sections of the country emphasizing the latest developments.

One factor in the selection of San Francisco was its rapidly expanding economy. The Bay Region has a population of 4,362,000. Over one quarter having settled there since 1950 and over one half since 1940. At the present growth of 10,433 persons monthly, the region's population is expected to reach 5,100,000 by 1965.

Plans for the 1961 Convention have been started by the Northern California Chapter, official hosts. S. D. Russell, Phoenix Iron Works, Oakland, former National Director, is the general conference chairman.

Committee chairmen are: Donald C. Caudron, Pacific Brass Foundry of San Francisco, hospitality; Charles R. Marshall, Industrial & Foundry Supply Co., Oakland, plant visitation; Robert A. Johnston, Brumley-Donaldson Co., San Leandro, shop course; Clayton D. Russell, Phoenix Iron Works, ladies entertainment; Hugh F. Prior, Superior Electrocast Foundry, San Mateo, Northern California Day; Lane M. Currie, H. C. Macaulay Foundry, banquet; J. M. Snyder, Joseph Musto-Keenan Co., Castro Valley, publicity; and Davis Taylor, Wheelabrator Co., San Carlos, secretary.

The Exposition will be held in the new underground, air-conditioned Brooks Hall. It is adjacent to the Civic Auditorium where the technical sessions will be held.

Approximately 100 representative papers will be presented at the Castings Congress. These will represent the latest investigations by the AFS Divisions and General Interest Committees. Authors will represent all phases of the industry and the United States and abroad.

Plans are being made for a post-Congress tour to Hawaii. Further details will be announced later.

AFS General Manager W. W. Maloney addressing meeting of the International Association of Convention Bureaus at the annual meeting held in San Francisco.

Brooks Hall in downtown San Francisco, site of the 1961 Exposition. Hall is adjacent to Civic Auditorium where technical sessions will be held.

DUCTILE IRON course held during June in Chicago was attended by 29 students from the United States, Canada, and Japan.

DUCTILE IRON course instructors and T&RI training supervisor conducted a panel on ductile problems. Left to right are V. H. Patterson, Vanadium Corp.; A. H. Rauch, Deere & Co.; H. O. Meriwether, Lynchburg Foundry Co.; R. E. Betterley.

DUCTILE IRON course sponsored by AFS Training & Research Institute had two visiting Japanese touring foundries in the United States. Shown in foreground are Kisao Abe and Yoichi Tamazaki.

Tennessee Conducts Course on Melting

Fundamentals of cupola melting of iron, co-sponsored by the AFS Tennessee Chapter and the AFS Training & Research Institute were presented July 25-29 at the Patten Hotel, Chattanooga, Tenn.

The course was designed for cupola operators, melting foremen, metallurgists, and supervisory personnel. Subjects included cupola design and construction; raw materials; purchasing and handling equipment; alloys; charge preparation; coke and bed preparation; cupola lining and maintenance; combustion in the cupola; metal control and cupola records; metallurgy of gray iron; and operating problems.

Instructors were Walter Jaeschke, Whiting Corp., Harvey, Ill.; T. E. Barlow, Eastern Clay Products Dept., Skokie, Ill.; Walter Levi, consultant, Radford, Va.; S. C. Massari, AFS Technical Director and H. J. Weber, AFS Director of Safety, Hygiene & Air Pollution Control.

AFS Training & Research Course Preview

Foundry Refractories **Sept. 12-14**
Intensive specialized instructive course, providing informative up-to-date technology on foundry refractories. Emphasis on types, selection, use, maintenance and economy in foundry practices. Course provides broad understanding of expendable foundry materials and how the intelligent use can reduce operating costs. Course designed for supervisors, foremen, technicians, engineers, and management. **Place: Chicago—Fee: $60.—Course No. 11**

Economical Purchasing of Foundry Materials **Sept. 26-28**
Course gives detailed instruction on intelligent buying of scrap, refractories, sand, alloys, binders, core oil, additives, etc. Includes up-to-date information on all aspects of foundry materials purchasing. Valuable to supervisors, engineers, purchasing agents, foremen, and management. **Place: Chicago—Fee: $60—Course No. 12**

Sand Testing **Oct. 10-14**
A working course involving demonstrations and laboratory work. Students perform sand tests and are checked by instructor. Basic tests and equipment are demonstrated with emphasis on correct procedures, sand properties, variables, and controls. Recommended for sand technicians, foremen, supervisors, trainees, and sales engineers. Class limited to 25. **Place: Detroit—$150.—Course No. 13**

Foundry Plant Layout **Oct. 24-26**
Instructive course on problems of remodeling or building of new plants. Materials handling equipment, shop routing, storage, cleaning, shipment of castings, safety and hygiene, and plant location are studied. Differences are job shops and production shops are also discussed. For foreman, managers, supervisors, plant and industrial engineers, and management. **Place: Chicago—Fee: $60.—Course No. 14**

Vancouver Host to 11th Annual Northwest Regional Conference

British Columbia Chapter members will be hosts to the 11th Annual Northwest Regional Conference to be held Oct. 21-22 at the Hotel Georgia, Vancouver, British Columbia.

Sponsors of the conference in addition to the British Columbia Chapter are the Oregon and Washington Chapters, and the Oregon State College Student Chapter. Herbert Heaton, Mainland Foundry Co., Ltd., Vancouver, British Columbia, is the general conference chairman.

The tentative program:

Friday, Oct. 21

Morning Technical Program

Iron Session—G. I. Pound, Dominion Bridge Co., Ltd., Calgary, Alberta.

Light Metals Session—Paul Hookings, Granby Consolidated, Allenby, British Columbia.

Pattern Session—W. Wenninga, Park-Hannesson, Ltd.

Afternoon Program

Plant visitation tours. Schedule to be announced at a later date.

Evening Program

Banquet—Hotel Georgia. Speaker, W. B. Johnson, Aluminum Co. of Canada.

Saturday, Oct. 22

Technical Meetings

Pipe Manufacturing—G. Harris, Anthes Imperial Co., Ltd., Edmonton, Alberta.

Cast Iron Melting Furnaces in Canada and Future Trends—F. W. Kellam, Metals & Carbon Div., Union Carbide Canada, Ltd., Toronto, Ontario.

Steel Melting in Hawaiian Plant—J. R. Belyea, Vancouver Steel Co., Ltd., Vancouver, British Columbia.

Educating Our Future Foundry Personnel—W. C. Catherall, Vancouver Technical School, Vancouver, British Columbia.

Ductile Iron—J. Provias, International Nickel Co., Ltd., Toronto, Ontario.

Luncheons will be held both days at the Hotel Georgia and a Saturday evening dance is scheduled for the Stanley Park Pavilion.

A ladies program is planned for Saturday.

Canadian Conference Oct. 27-28

Seventeen technical sessions representing sand, iron, steel, and nonferrous interests will be presented at the All-Canadian Conference to be held Oct. 27-28 at the Sheraton-Mt. Royal Hotel, Montreal.

Five outstanding plants in the Montreal area will be open for visits in the mornings. These are:

Montreal Bronze Co., Ltd., the largest of the Canadian non-ferrous jobbing foundries.

Dominion Engineering Works, Ltd., the largest integrated captive group of Canadian foundries with steel, iron, and brass foundries.

Canadian Steel Foundries, Ltd., the largest Canadian steel foundry.

Canadian Steel Wheel, Ltd., a completely automated production unit, the first of its kind in Canada.

Warden King, Ltd., a high production iron foundry.

Max Reading, Foundry Services (Canada) Ltd., is chairman of the conference sponsored jointly by the Eastern Canada and Ontario Chapters. Co-chairmen are A. K. Durrell, Dominion Engineering Works, Ltd.; W. Tibbits, Canadian Steel Foundries, Ltd.; and M. Trottier, Quebec Iron & Titanium Corp.

Topics to be covered by speakers from Canada and the United States include: Benefits of Slurry in Foundry Sands; Mold and Core Washes; Determination of True Clay Content; The Scab Test Block Casting in Sand Control; Self-Service Mixing Ladle at Cupola; Cast Iron Melting Furnaces in Canada and Future Trends; Some Controls, Some Properties, Some Production Techniques of Ductile Cast Irons; Direct-Arc Steel Melting in the Foundry; Welding as Applied to Foundries; Construction Problems of Large Pattern Equipment.

M. Reading

Also: Selection and Application of Copper-Base Alloys in Industry; Some Recent Developments in the Metallurgy of Aluminum Foundry Alloys; Some Casting Defects, Their Causes and Cures as Applied to Non-Ferrous and Light Alloys.

Convention headquarters will be in the Sheraton-Mt. Royal Hotel with registration starting Oct. 26.

Eight Conferences Set for 1960-61

Eight regional conferences will be held in Canada and the United States throughout the 1960-61 program year. Six are annual conferences and two are held on a two-year frequency.

The conferences are:

New England Regional . . . Oct. 14-15
Location: Massachusetts Institute of Technology, Cambridge, Mass.
Sponsors: New England Chapter and Massachusetts Institute of Technology Student Chapter.

Northwest Regional . . . . . Oct. 21-22
Location: Georgia Hotel, Vancouver, British Columbia.
Sponsors: British Columbia, Oregon, and Washington Chapters and the Oregon State College Student Chapter.

All-Canadian Regional . . . . Oct. 27-28
Location: Mt. Royal Hotel, Montreal, Quebec.
Sponsors: Eastern Canada and Ontario Chapters.

Purdue Regional . . . . Oct. 27-28
Location: Purdue University, Lafayette, Ind.
Sponsors: Central Indiana and Michiana Chapters with Purdue University Student Chapters.

Michigan Regional . . . . Nov. 3-4
Location: Bancroft Hotel, Saginaw, Mich.
Sponsors: Central Michigan, Detroit, Saginaw Valley, and Western Michigan Chapters.

Wisconsin Regional . . . . . . Feb. 9-10
Location: Schroeder Hotel, Milwaukee.
Sponsors: Wisconsin Chapter in cooperation with the University of Wisconsin.

Southeastern Regional . . . Feb. 16-17
Location: Read House, Chattanooga, Tenn.
Sponsors: Birmingham and Tennessee Chapters, and University of Alabama Student Chapter.

Penn State Regional . . . . June 22-24
Location: Penn State University, University Park, Pa.
Sponsors: Central New York, Chesapeake, Eastern New York, Metropolitan, Northwestern Pennsylvania, Ontario, Philadelphia, Pittsburgh, Rochester, and Western New York Chapter.

Competition Opens Oct. 1 in Apprentice Contest

Competition opens Oct. 1 in the annual AFS Robert E. Kennedy Memorial Apprentice Contest. All entries for national competition must be submitted by March 31, 1961.

The contest, started in 1924, is open to any apprentice, learner or trainee in the metalcasting industry who has not had more than five years patternmaking experience, nor more than four years molding experience. The amount of apprentice training or other training completed has no bearing on eligibility. Membership in the American Foundrymen's Society is not required by the apprentice nor his company.

Competition is open in five categories; wood patternmaking, metal patternmaking, iron molding, steel molding, and non-ferrous molding. Judging of national contest entries is conducted on a point-score basis determined by the Apprentice Contest Committee of the Education Division.

Rules Changes

The only rules changes made by the Apprentice Contest Committee meeting at its May meeting involves molding regulations. These are:

Ingates, riser connections and runners must be cut by hand.

A selection of pre-formed sprue pins and risers shall be provided by the participating foundry.

The use of follow board or preformed supports blocks will not be permitted.

Prizes and Awards

Cash prizes will be awarded in each of the five divisions as follows: first place, \$100; second place, \$75; third place, \$50. Certificates of recognition signed by the Society President will be given to all winners in each of the divisions. The first place winner in each division will be invited to attend the 1961 Convention in San Francisco to receive his award in person. AFS will assume the first place winners' round-trip travel expense to and from San Francisco. All other expenses shall be assumed by the winner, his company, or his local chapter.

Local Contests

Local contsts may be held under the auspices of AFS Chapters, or by individual plants acting separately or in a group, to determine which castings and patterns shall be entered in the national contest. The official 1961 rules and regulations for national competition shall apply for all local contests.

Society Sponsors 10 Investigations

In a search for basic technical information, ten research projects are currently sponsored by the AFS Training & Research Institute under direction of five technical divisions.

A report on the status of these investigations was made at the Technical Council meeting in June. Briefly summarized, these include:

Sand Research—

CORE TEST COMMITTEE: In process of developing tests for core sand mixtures bonded with either air-setting binders, or sodium silicate CO_2 types.

PHYSICAL PROPERTIES OF IRON FOUNDRY MOLDING MATERIALS AT ELEVATED TEMPERATURES COMMITTEE: Used facilities at the University of Illinois for making test molds and pouring them.

GREEN SAND PROPERTIES COMMITTEE—Continuing its research.

BASIC CONCEPTS COMMITTEE—Studying behavior of granular materials, using glass beads to establish fundamental data.

CONTROLLED CASTING COMMITTEE—Acquiring photographs for use in book which will be substantially a revised edition of the former book on ANALYSIS OF CASTING DEFECTS.

MOLD SURFACE COMMITTEE—Work in progress which will involve surfacing measuring equipment, pattern equipment and statistical computations.

GRAY IRON RESEARCH—Investigation at Case Institute of Technology, Cleveland, is being conducted on the establishment of factual data relative to the feeding distance of various sized risers in simple geometrical forms.

The project, started about a year ago, discloses that if gray iron is poured into a comparatively rigid mold, many castings can be made satisfactorily without the use of risers, since most riser requirements are necessitated by mold wall movement rather than inherent shrinkage of the metal itself.

BRASS & BRONZE RESEARCH—Investigation is underway at the University of Michigan on the establishment of the feeding distance for the casting of 85-5-5-5 metal.

MALLEABLE RESEARCH—Investigation at the University of Wisconsin is being done on the possibility of producing heavy section malleable castings without the presence of primary graphite in the white castings. Conclusions of the investigation are expected soon.

STEEL RESEARCH—Investigation at the University of Michigan is producing the first basic information on the cause of snotters or ceroxide. Two cause of snotters or ceroxide.

Hewitt Becomes Exhibit Manager

Richard J. Hewitt has been named AFS Convention and Exhibit Manager. He has 25 years' experience in hotel sales, exhibit, and association activities. For the past four years he has been associated with the Master Photo Dealers and Finishers Association as executive assistant manager and director of trade shows and conventions.

R. J. Hewitt

Hewitt started in the hotel business in 1937, served as a 1st Lieutenant in the U.S. Army during World War II, and after his discharge became sales representative of the Statler chain executive office.

In 1951 he was named sales manager of the new Hotel Statler in Los Angeles. When Hilton purchased the Statlers he was named western division sales manager, planning and supervising convention solicitation for eight hotels from California to Texas.

D. C. Rose, Wedron Silica Co., Chicago, and Richard Kirsop, Thiem Products Co., Milwaukee, set cores in place at working meeting of the committee.

D. C. Williams, associate professor, metallurgical engineering, Ohio State University, Columbus, Ohio, examines test castings made in steel. Castings were also made in cast iron, brass, aluminum, and magnesium.

Mold Surface Group Conducts Investigation

Investigations into the study of mold surface problems were continued during June at the Magnet Cove Barium Corp. foundry, Arlington Heights, Ill., by the Sand Division Mold Surface Committee.

Steel, cast iron, brass, aluminum, and magnesium were poured against special cores. Four castings were made from each metal.

Prior to casting, surface finish measurements were made on the cores which had AFS grain finenesses of 50, 80, 110, and 140. During the work session, surface finish traces were made on cores in designated areas.

As designed, the mold was to cast the cored surface flush on the drag side. To permit easier removal and measurement of the cores surfaces, cores were set to have the surface occur on a 1-1/8x1/4 inch boss.

Pouring temperatures were: steel, 2850-2900F.; cast iron, 2650F.; brass (85-5-5-5), 2250F.; aluminum (356), 1400F.; magnesium (AZ91), 1360F. for first casting and 1400F. for the remaining three.

Profiling, microscopic, and other means of surface measuring will be performed on the castings.

Members attending were: G. J. Vingas, Magnet Cove Barium Corp.; J. E. Haller, James B. Clow & Sons, Inc., Coschocton, Ohio; J. B. Caine, consultant, Cincinnati; Randolph Dietert, Harry W. Dietert Co., Detroit; R. M. Gregory, Archer-Daniels-Midland Co., Cleveland; D. C. Rose, Wedron Silica Co., Chicago; R. W. Ruddle, Foundry Services, Inc., Cleveland; C. J. Schwetz, Thiem Products, Inc., Milwaukee; D. C. Williams, Ohio State University, Columbus, Ohio; J. G. House, Dow Chemical Co., Bay City, Mich.

Core Test Group Studies CO_2

Sand permeability has a definite effect on the ease of obtaining higher strengths in sodium silicate bonded sands cured with carbon dioxide.

This and other observations resulted from a work session held earlier this year at the University of Illinois by the Sand Division Core Test Committee. The effectiveness of time and pressure regulations on carbon dioxide curing of sodium silicate bonded sand was investigated.

The dry shear strength test was selected to use existing testing equipment, and also due to the fact that sands bonded, develop strengths too great for dry compressive strengths on foundry equipment. Tensile strengths for sands so bonded, remain a possibility but it was felt that the dry test would give more accurate indications of comparative strengths.

Three basic sand mixtures were used: washed and dried silica sand, lake sand, and 75 per cent lake—25 per cent bank sand. These were bonded with three and five per cent sodium silicate. Carbon dioxide was applied to the rammed specimens at pressures of 10, 20, 30, and 40 pounds per square inch for periods of 5, 15, 30, and 50 seconds.

Early in the investigation it was found that the CO_2 temperature was very important so it was necessary to bring the gas to a constant temperature.

The tests further indicated that:

Increased strength may be obtained by increased pressure and increased time.

The time exposure to CO_2 has a greater effect on sand strength than gas pressure.

Mold or core hardness is not an effective means of determining comparative results on silicate bonded sands.

No optimum values were obtained. No limit was obtained on shear strength with continued increase of pressure and time

At lower pressure, longer gassing time is needed to equal the same high strengths obtained with higher pressure.

There was no evidence of over-gassing or over-curing.

Lower permeability sands achieve higher strengths in shorter times and at lower pressures.

Venting of the core box produces a more positive and predictable curing action because of better diffusion and direction of flow.

Twin City Education Program Brings Story of Casting Industry to Students, Teachers

An ambitious educational program is being conducted in Minnesota by the AFS Twin City Chapter. It is designed to familiarize teachers and students with the principles of metal casting, to show job opportunities in the foundry industry, and to acquaint the public with the function and status of the foundry industry in the industrial community.

Six elements are involved in the program, entitled "The Birth of a Casting":

1–A display of step-by-step procedures in the making of a casting, in this case, an intake manifold for a portable generator. Included are blueprints, master pattern, a matchplate, complete cope and drag, castings plus the gating system, and the final product.

2–A talk explaining and amplifying the manufacturing and planning steps.

3–A 40-slide presentation of the latest in foundry equipment and techniques.

4–A question and answer period.

5–A post-program plant visitation tour of local foundries.

6–A general descriptive letter sent to various industrial arts instructors outlining the aims of the program.

Prior to outlining the manufacturing steps, common foundry products are mentioned and emphasis placed on the vital but unseen role of castings as component parts.

A discussion of the role of the design engineer points out that he must consider the requirements, cost, and appearance of the finished product before deciding upon the manufacturing method.

Casting was chosen for the intake manifold because of its irregular shape and aluminum was selected as the metal because of its weight advantage.

Next the role of the patternmaker is discussed. He considers the size and design of the part, quantity, and method of molding before determining the type of pattern equipment. In this case, the solution involved a master pattern, matchplate, and a core box with driers. Special mention is made of the shrinkage allowance and the close cooperation between the patternmaker, designer, and foundryman before production patterns are completed.

In outlining foundry procedures the description begins with the making of cores followed by explanations of foundry sands, molds and molding procedures, pouring, metallurgy, cleaning, and finishing.

After the story of "The Birth of a Casting," the CO_2 process is demonstrated.

Presentation of the program is made by a two-man team, one a hold-over and one a rookie who handles the presentation at the next meeting.

An important part of the program are the visits to local foundries. Here the student sees first hand all that he has been told or shown. Both Minneapolis and St. Paul foundries have been cooperative in opening their plants.

Education committee members are: chairman, Frank Ryan, St. Paul Brass Foundry Co.; vice-chairmen, Doug Schuler, American Hoist & Derrick Co.; John Heitkamp, Northern Malleable Iron Co.; Fred Junger, Prospect Foundry Co.; Mel Schroeder, Prospect Foundry Co.; Ted Serakos, Minneapolis Electric Steel Castings Co.; John Entenmann, Northern Malleable Iron Co.; and Dick Schlemmer, American Hoist & Derrick Co.

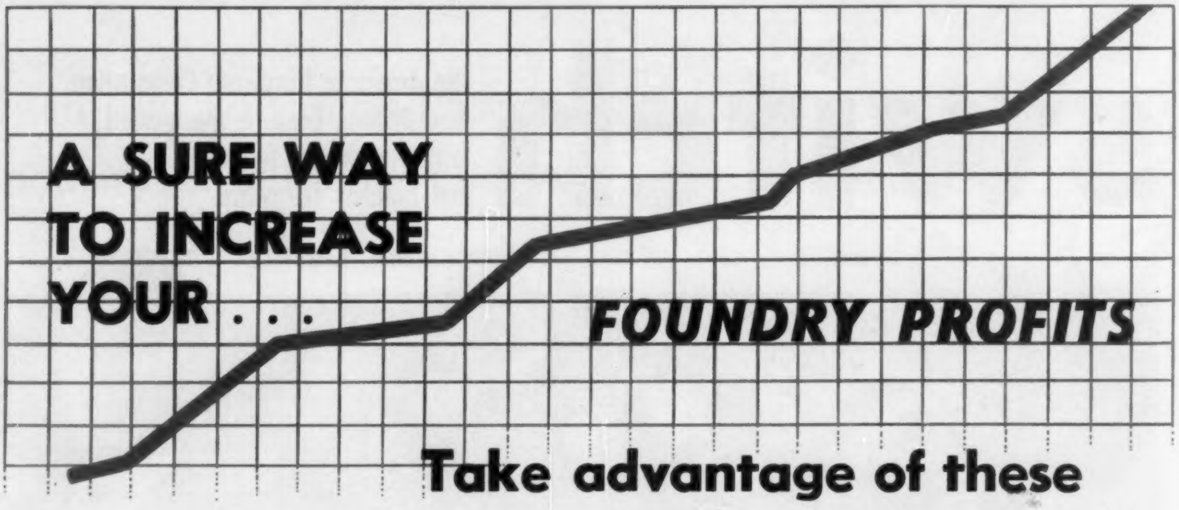
by Matt Granlund
Archer-Daniels-Midland Co.
Minneapolis

Students study blueprints of intake manifold which is featured in chapter's display.

John Heitkamp, Northern Malleable Iron Co.; George Jaeger, St. Paul industrial arts instructor, and Frank Ryan, St. Paul Brass Foundry Co.; discuss the presentation.

Dale Anderson, Minneapolis Electric Steel Castings Co., describes various physical tests to students on plant tour.

Students view Twin City's display, "Birth of a Casting," which traces the steps from blueprint to finished product.



Take advantage of these

PLUS VALUES

USE ABC FOUNDRY COKE!

HIGHEST FIXED CARBON . . . ABC standard foundry coke improves melting ratios . . . is most efficient for gray iron cupola melting.

CONSISTENT QUALITY . . . ABC's laboratory staff maintains close chemical and physical control and supervises daily operations of our production-size test cupola.

UNIFORM COKE SIZE . . . Each carload is carefully screened to sizes "Just Right" for every cupola requirement.

PRODUCTION-SIZE TEST CUPOLA . . . Only ABC maintains this facility for regular checks of carbon pick-up and temperatures. Results are available to ABC customers to help forecast coke performance.

EXPERIENCED MELTING SERVICE . . . ABC's staff of practical cupola service engineers has unexcelled experience and is always ready to help users produce better castings at lower melting costs.

ABC produces standard foundry coke for gray iron melting and several grades of special and malleable foundry cokes. Whatever your carbon pick-up requirement, be it high, medum or low, ABC has a coke tailored for your need. ABC's annual productive capacity of over 900,000 tons of strictly merchant coke is your assurance of dependable service under all conditions of supply and demand. Forty years of experience in the production of premium quality foundry coke is your guarantee of better melting with fewer rejects and higher profits.

A TRIAL ORDER WILL CONVINCE YOU!

General Sales Office:
First National Building
Birmingham, Alabama

ALABAMA BY-PRODUCTS CORPORATION

Sales Agents:
Great Lakes Foundry Sand Company, Detroit; St. Louis Coke & Foundry Supply Co., St. Louis; The Ranson and Orr Company, Cincinnati; Kerchner, Marshall and Company, Pittsburgh; Balfour, Guthrie & Company, Ltd., San Francisco; Anselman Foundry Services, St. Charles, Illinois

Circle No. 148, Page 147

CHAPTER NEWS

Tennessee Holds Education Session on Shell Cores, Molds

TENNESSEE—Panel members at the shell core and mold program were: Albert Waller, Ross-Meehan Foundries, Inc.; Coy Jones, Mueller Co.; Karl Landgrebe, Ben Seymour, and Forest Varnell of Wheland Co.

TENNESSEE—Charles Chisholm, Wheland Co., Ray Olson, Southern Precision Pattern Works, and Ben Seymour, Wheland Co., examine display of shell cores and molds.

NORTHEASTERN OHIO—It's the end of the trail for Al Skok, Steve Miller, H. R. Street, and William Street who competed in chapter's golf tournament.—by Harold Wheeler

Tennessee Chapter

Studies Shell Cores, Molds

A special educational session on shell molds and cores was held during April when 65 foundrymen visited the Wheland Co., Chattanooga, Tenn.

A. B. Helms, chapter education chairman and Wheland production control superintendent, planned the meeting on shell mold and shell core processes.

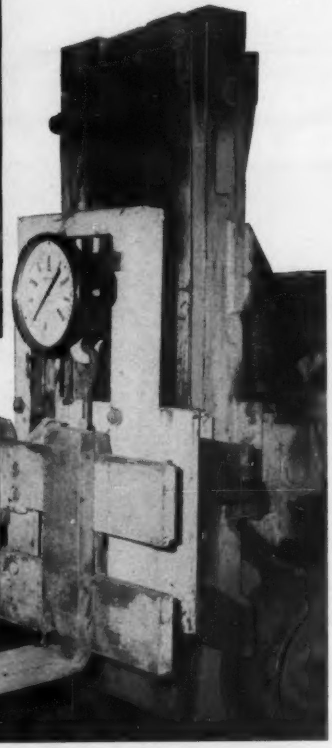
Following a tour of Wheland's shell mold and core facilities, a panel discussion was conducted. Members were: Albert Waller, Ross-Meehan Foundries, Inc.; Coy Jones, Mueller Co.; and Ben Seymour and Forest Varnell of Wheland Co. Karl L. Landgrebe, Wheland Co., served as moderator.

A display of cores and molds were provided by Wheland Co., and foundries in South Pittsburg, Nashville, and Birmingham, Ala. Members of the Birmingham Chapter also attended the meeting.

NORTHEASTERN OHIO—Relaxing in golfing cart are Robert McCune, Edward Bugajski, and Robert K. Kelly, of Allyn-Ryan Foundry Div., Superior Foundry, Inc. Annual outing was held in June.—by Harold Wheeler.

OREGON—Golf tournament chairman, Cliff Holmes, Northwest Foundry & Furnace Co., checks golf entries at tournament.—by Bill Walkins

View of Gray Iron Pallet System. Pallets can be easily moved over rails by hand. Left: Plant Engineer Robert H. Clarke. Right: Scale mounted on fork truck weighs each component of charge.



ENGINEERING APPLICATIONS PAY OFF AT DALTON FOUNDRIES

INCREASED EFFICIENCY To obtain faster, more efficient, production in the company's gray iron foundry, Robert H. Clarke, Plant Engineer at Dalton Foundries, Inc., Warsaw, Indiana, designed a pallet system. This flexible system allows molders to work two hours before pouring needs to begin. Cooling time can be varied to suit the job and pallets can be easily moved over rails by hand. No bottom boards are used and the handling formerly required to bring them back to the molders has been eliminated. The pallet system provides flexibility for both production and jobbing type work.

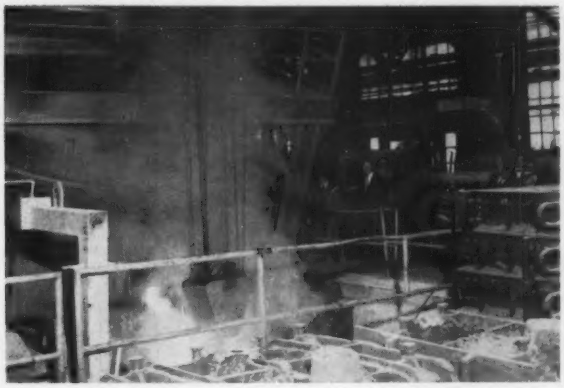
BETTER CONTROL When bond and water are added to sand during mulling, the bond must be thoroughly combinded with water to be effective. Plant Engineer Clarke designed a system to pre-mix water and bond, and pump the mixture into a storage tank where it is stirred continually. From the storage tank, small amounts of the mixture are metered into a tank by a timer. Compressed air then blows this metered amount into the muller at the correct time. This system has resulted in better control of sand, faster mulling cycles, and easier handling of materials.

LOWER COST At the Dalton Foundries the old wheelbarrow method used to charge the cupola required seven men. Clarke designed a scale which could be mounted on the front of a fork truck to weigh each component of the charge as it was loaded into a drop-bottom tub on the truck. After it is loaded, the fork truck delivers the material to the charging bucket. This simple, and inexpensive engineering change reduced the labor requirement to three men instead of the seven previously required.

You can help create a source of engineering talent for the foundry industry by participating in the FEF program as a contributing member.

Foundry Educational Foundation

1138 TERMINAL TOWER BUILDING • CLEVELAND 13, OHIO



Tapping the heat from a 17-ton arc furnace at the General Electric Co., Schenectady, N. Y., foundry.

Pouring of turbine housings witnessed by members of the Eastern New York Chapter on plant visitation.

Eastern New York Chapter Participates In Plant Tour

Sixty members in March participated in a combined plant visitation and technical session stressing the design and use of castings for steam turbines.

Visits were made to the General Electric Co., Schenectady, N. Y., iron foundry, steel foundry, patternshop, and large steam turbine and generator plant.

In the iron foundry, members watched the pouring of castings from a 17-ton arc furnace and later witnessed cleaning and snagging operations on these castings. An example of the foundry practice was the use of steel inserts to form the diaphragm blades for steam turbines.

In the steel foundry, a recently installed 100-ton arc furnace was explained and members shown 25-ton castings poured from this unit. Due to relining operations, the furnace was not in operation. However, a tour was made of the power room and the principles of its operation were described.

Also in the steel foundry, sand molding procedures were observed using both conventional methods and the cold-set process.

The manufacture of wood, steel, and plastic patterns were seen in the patternshop. In addition, demonstrations were made of how changes in design and manufacture bring about corresponding changes in pattern equipment.

The final stop of the tour was the large steam turbine and generator building where all armatures and generator housings are given final machining operations.

Following the plant tour and a dinner, Leo Songer, General Electric Co., discussed the design and use of castings for steam turbines.—by L. C. Johnson.

AFS Chapter Meetings

SEPTEMBER

Birmingham District . . Sept. 10 . . Cascade Plunge, Birmingham, Ala. . . *Annual Outing.*

British Columbia . . Sept. 16 . . Vancouver, B.C. . . H. J. Weber, American Foundrymen's Society, *"Loss of Hearing Due to Industrial Noise."*

Central Illinois . . Sept. 10 . . 497th Engineers Club, Peoria, Ill. . . *Fish Fry.*

Central Indiana . . Sept. 10 . . Lake Shore Country Club, Indianapolis . . *Annual Picnic.*

Central Michigan . . Sept. 21 . . Hart Hotel, Battle Creek, Mich.

Central New York . . Sept. 9 . . Trinkhause Manor, Oriskany, N.Y.

Central New York, Southern Tier Section . . Sept. 16 . . Imperial Club, Painted Post, N.Y.

Central Ohio . . Sept. 12 . . Seneca Hotel, Columbus, Ohio . . C. A. Sanders, American Colloid Co., *"Sand."*

Chesapeake . . Sept. 23 . . Allan Wood Steel Co., Conshohocken, Pa. . . *Visitation.*

Cincinnati District . . Sept. 10 . . Wigwam Restaurant, Cincinnati.

Connecticut . . Sept. 27 . . Waverly Inn, Cheshire, Conn. . . T. E. Barlow, Eastern Clay Products Dept., International Minerals & Chemical Corp., *"Green Sand Molding."*

Corn Belt . . Sept. 23 . . Marchio's Steak House, Omaha, Neb. . . H. J. Weber, American Foundrymen's Society, *"Loss of Hearing Due to Industrial Noise."*

Detroit . . Sept. 22 . . Wolverine Hotel, Detroit . . E. J. Walsh, Foundry Educational Foundation, *"Foundry Education & The Challenge of the Sixties."*

Eastern New York . . Sept. 20 . . Panetta's Restaurant, Menands, N.Y.

Mid-South . . Sept. 9 . . Claridge Hotel, Memphis, Tenn.

Mo-Kan . . Sept. 22 . . Fairfax Airport, Kansas City, Kans. . . H. J. Weber, American Foundrymen's Society, *"Loss of Hearing Due to Industrial Noise."*

New England . . Sept. 14 . . University Club, Boston.

Northeastern Ohio . . Sept. 8 . . Tudor Arms Hotel, Cleveland.

Northern Illinois & Southern Wisconsin . . Sept. 13 . . Morse Hills Country Club.

Northwestern Pennsylvania . . Sept. 26 . . Amity Inn, Erie, Pa. . . H. J. Heine, Malleable Founders Society.

Ontario . . Sept. 23 . . Royal Connaught Hotel, Hamilton, Ont.

Oregon . . Sept. 14 . . Park Heathman Hotel, Portland, Ore. . . H. J. Weber, American Foundrymen's Society, *"Safety and Hygiene."*

Piedmont . . Sept. 9 . . Sedgefield Inn, Greensboro, N.C. . . J. A. Westover, Westover Corp., *"Profits & Costs."*

Continued on page 136

Pittsburgh . . **Sept. 19** . . Hotel Webster Hall, Pittsburgh, Pa. . . A. B. Sinnett, American Foundrymen's Society, *"What AFS Can Do for You."*

Quad City . . **Sept. 19** . . LeClaire Hotel, Moline, Ill. . . J. H. Schaum, Modern Castings, *"What's New in Metalcastings."*

St. Louis District . . **Sept. 8** . . Edmonds Restaurant, St. Louis . . V. E. Lich, General Steel Castings Corp., *"Maintenance & Material Handling."*

Southern California . . **Sept. 9** . . Furniture Mart, Los Angeles . . H. J. Weber, American Foundrymen's Society, *"Methods of Controlling Heat in the Foundry."*

Tennessee . . **Sept. 24** . . Camp Columbus, Chattanooga, Tenn. . . *Outing.*

Texas . . **Sept. 9** . . Houston Engineering & Scientific Society, Houston, Texas . . J. R. Hewitt, Crouse-Hinds Co., *"Gating & Risering of Steel."*

Timberline . . **Sept. 21** . . Denver, Colo. . . H. J. Weber, American Foundrymen's Society, *"Loss of Hearing Due to Industrial Noise."*

Twin City . . **Sept. 13** . . Jax Cafe, Minneapolis . . S. Munson, Ren Plastics, Inc., *"Plastics in Patternmaking."*

Utah . . **Sept. 20** . . Salt Lake City . . H. J. Weber, American Foundrymen's Society, *"Loss of Hearing Due to Industrial Noise."*

Washington . . **Sept. 15** . . Seattle . . H. J. Weber, American Foundrymen's Society, "Industrial Hygiene & Air Pollution."

Wisconsin . . **Sept. 9** . . Schroeder Hotel, Milwaukee . . *Sectional Meetings.*

OCTOBER

All Canadian Regional Foundry Conference . . **Oct. 27-28** . . Mt. Royal Hotel, Montreal, Que.

Birmingham District . . **Oct. 14** . . Thomas Jefferson Hotel, Birmingham.

British Columbia . . *See Northwest Regional Foundry Conference.*

Canton District . . **Oct. 6** . . Town & Country Restaurant, Canton, Ohio. .

Central Illinois . . **Oct. 3** . . Vonachen's Junction, Peoria, Ill.

Central Indiana . . **Oct. 3** . . Athenaeum Club, Indianapolis . . C. A. Sanders, American Colloid Co., *"New Coring Methods."*

Central Michigan . . **Oct. 19** . . Hart Hotel, Battle Creek, Mich.

Central Ohio . . **Oct. 10** . . Seneca Hotel, Columbus, Ohio . . J. A. Gitzen, Delta Oil Products Co., *"Sand Binders & Coatings."*

METALGRAMS

UNION CARBIDE METALS

Electromet brand ferroalloys, pure metals and metal chemicals

. . . news of "Electromet" ferroalloys and metals

SEPTEMBER, 1960

HIGHER DUCTILITY WITH CALCIUM-SILICON -- Two Midwestern steel foundries recently obtained data on Grade B steel castings made with and without calcium-silicon. In one test of 91 production heats, all of the heats treated with calcium-silicon and aluminum produced castings with satisfactory ductility. As a comparison, over 25 per cent of the heats deoxidized only with aluminum failed to meet reduction-in-area specifications. In another test of 20 production heats, a 15 to 20 per cent improvement in ductility (% RA) was reported.

* * *

BETTER FLUIDITY TOO -- American Hoist and Derrick Co., St. Paul, Minn., also reports improved fluidity of Grade B steel when treated with 6 lbs. per ton of calcium-silicon. Although they now pour several thin-sectioned castings in a single mold at lower temperatures than before, they have had no misrun castings. On a test of 58 production heats they also report 20 to 25 per cent improvement in ductility with the use of calcium-silicon. Further data can be obtained by writing for the article, "Calcium Improves Ductility of Steel Castings," in the Summer 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

MORE ELECTROLYTIC MANGANESE -- To meet the increasing demand for "Elmang" electrolytic manganese metal, Union Carbide Metals has expanded its cell capacity by 20 per cent. Hence, a larger supply of this high-purity product (99.9 per cent minimum manganese) is assured for additions to steel, copper, and aluminum. Also of interest: (1) The metal is now available in 50-lb. bags for convenient, accurate additions. (2) The 600-lb. drums of "Elmang" manganese are now color-coded to allow easy identification of the regular, deyhydrogenated, and nitrogen-bearing grades. Write for new specifications sheet F-20,151.

* * *

SERVICE ON THE MOVE -- Every year, experienced metallurgists of UCM's Metallurgical Service Division travel tens of thousands of miles to customers' plants. Their mission: to provide on-the-site help on the use of ferroalloys and alloying metals in melting operations. As an example, a Metallurgical Service representative worked with Electric Steel Foundry Company of Portland in evaluating the new fast-dissolving "Simplex" ferrochrome in stainless steel. The joint effort showed that 5- to 7-minute savings in furnace time could be made per 2,000 lb. heat. For a detailed picture story of this cooperative service, write for "Service on the Move" in the Winter 1960 issue of UNION CARBIDE METALS REVIEW.

* * *

BETTER PROPERTIES FOR HIGH-STRENGTH IRON -- Foundrymen melting high-strength cast iron must keep their carbon low to minimize the weakening effect of graphite. By doing so, however, they often run into machining problems and low properties due to an abnormal structure. The remedy used by many foundrymen is "SMZ" alloy. This ladle addition improves machinability, promotes a uniform structure between light and heavy sections, and insures high-strength values. About 10 lbs. per ton are added to a 3 per cent carbon, 1.70 per cent silicon iron to get 40,000 to 50,000 psi. Write for F-4604C for more information.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 270 Park Ave., New York 17, N. Y. In Canada: Union Carbide Canada Ltd., Toronto.

Foundry Trade News

American Steel Foundries . . . had increased sales and income in the first nine months of its 1960 fiscal year. Net income amounted to $5,917,947, equal to $2.02 per share, in the nine months ended June 30, 1960, as compared to $4,953,049, equal to $1.89 per share, in the corresponding period a year ago. Sales in the nine months increased to $91,953,439 from $82,478,669.

Deming Co. . . . Salem, Ohio, has increased foundry production 25 per cent with a modernization program. The foundry automation is part of a total tooling-up operation.

General Steel Castings Corp. . . . Granite City, Ill., has purchased the name, physical assets and business of St. Louis Car Co., a major supplier of railroad and rapid transit equipment. Operations of St. Louis Car Co. will continue as at present and the management and employment will continue without charge.

Precision Castings Co. . . . Cleveland, in June acted as host to the top operating officials of 63 of its vendor companies. The 52-year old company was acquired this year by Fulton Industries, Inc.

Gray Iron Founders' Society . . . has elected John E. McIntyre, Sibley Machine & Foundry Co., South Bend, Ind., as vice-president. He fulfills the unexpired term of J. E. Quest who has left the foundry industry.

Baldwin-Lima-Hamilton Corp. . . . Electronics & Instrumentation Div., has transferred its testing machine product line to Wiedemann Machine Co., King of Prussia, Pa. This transfer covers the physical testing machine business only and does not include the SR-4 strain gages, transducers, and instrumentation.

International Minerals & Chemical Corp. . . . Skokie, Ill., has reorganized its Industrial Minerals Div. Two departments have been consolidated into one sales and production organization. These are Eastern Clay and Consolidated Feldspar. E. W. Claar, former manager of the Eastern Clay Department becomes general manager. C. P. Loucks, former production manager for Eastern Clay, has been named general production manager for the division. T. E. Barlow, foundry sales manager, E. W. Koenig, ceramic sales manager, and W. K. Burriss, field sales manager, will report to Claar.

American Brake Shoe Co. . . . reports net earnings for the second quarter of 1960 of $2,098,808, equal to $1.29 per common share, up from 64 cents in the first quarter. However, earnings were below the $1.96 per share realized in the pre-steel strike second quarter of 1959.

Magnesium Association . . . will hold its 16th annual convention Oct. 17-19 at the Pick-Carter Hotel, Cleveland. Technical sessions, open to all, will be held for both mornings and afternoons of Oct. 17 and 18 with a final session the morning of Oct. 19. Twenty-odd papers will be presented.

Gray Iron Founders' Society . . . will hold its 32d annual meeting at the Netherland Hilton Hotel, Cincinnati, Oct. 12-14. An appraisal of problems and opportunities in the gray iron castings industry will be the theme. President A. M. Nutter will preside.

Speakers include: Tom Campbell, editor, Iron Age magazine; O. R. Strackbein, chairman, The Nation-Wide Committee on Import-Export Policy, Washington, D. C.; James A. Wyatt and Harry Figgie, Booz Allen & Hamilton, New York; Dr. G. Herbert True, Visual Research, Inc., South Bend, Ind.; and H. W. Lownie, chief, process metallurgy research, Battelle Memorial Institute, Columbus, Ohio.

John Ashby, advertising consultant and Peter R. Rentschler, chairman of the G.I.F.S. advertising committee, will review problems in connection with industry advertising. Richard Meloy, marketing director, will explain methods in promoting the film program. Allen Gray, editor, Metal Progress magazine, chairman of the 1960 design contest judging committee, will make formal presentation of awards.

A ladies program has also been arranged.

Shalco Div. . . . National Acme Co., Cleveland, has discontinued operations at Palo Alto, Calif. All operations are now moved to Cleveland.

Dow Chemical Co. . . . Midland, Mich., is reorganizing its marketing and sales development activities for consumer products. A sales development group will be organized to assist existing product departments in the evaluation of potentials for new consumer products. In addition, a consumer products marketing group is being formed to provide a central marketing organization for the products of Dow's various product departments and manufacturing divisions. Both groups will report directly to the general sales manager of the company.

C. O. Bartlett & Snow Co., Cleveland, this year marks its 75th year in business. The company started with the hand dressing of stone wheels for the milling of grain. It became a pioneer in foundry mechanization about 1910. Photo shows a Bartlett-Snow float in an 1895 industrial parade.

out-produces any other machine in its class!

F. E.'s *high speed* FLASKLESS MOLDING MACHINE

- Casting finish and accuracy top quality.
- Cope and drag molds made simultaneously.
- Molds move out onto roller conveyor.
- Patterns changed in but a few seconds.
- Power-operated head.
- Adjustable, slow draw.
- Power-operated pattern carrying frame.

Here's really fast, economical mold production — *without* the usual, heavy investment in flasks. You need only standard 16"x22" patterns and bottom boards as supplementary equipment. Flask equipment is an integral part of the machine!

One-man, semi-automatic operation — with all pressure and draw movements remotely controlled. Control pedestal may be located for left or right hand operation.

Economical maintenance, too. Oil-hydraulic operation in closed circuit, at 1200 p.s.i. — non-rusting, non-freezing, no long pipe lines, no pressure loss.

Write, wire or phone for complete details.

F. E. NORTH AMERICA, LTD.

47 ADVANCE ROAD, TORONTO 18, ONTARIO, CANADA

TELEPHONE: BELMONT 3-3227 • **TELEGRAMS:** EQUIPMENT, TORONTO

MOLDING MACHINES • SANDRAMMERS • SHELL MOLD AND CORE MACHINES • COMPLETE SAND HANDLING SYSTEMS

Circle No. 151, Page 147

Let's Get Personal . . .

P. L. McCulloch

W. D. Raddatz

G. H. Clamer

Stuart Z. Uram . . . formerly with the metallurgy department of Massachusetts Institute of Technology, has joined the metallurgical staff of Hitchiner Mfg. Co., Milford, N. H.

Williard Roth . . . is now assistant chief engineer for industrial furnaces and equipment, Sunbeam Equipment Corp., Meadville, Pa. He was manager of engineering for the industrial division of Lindberg Engineering Co., Chicago.

B. D. Claffey . . . vice-president of Dayton Malleable Iron Co. since 1958, has been appointed general director of the Ohio Malleable Div. at Columbus, Ohio, and the G.H.R. Foundry Div. at Dayton, Ohio. Claffey has been general manager of the G.H.R. Div. for several years. **Kenneth Henry**, general superintendent of the G.H.R. Div., has been named plant manager of that division. **D. L. Mains** continues as vice-president and general manager of the Columbus plant.

LeRoy Taylor . . . formerly manager of foundry sales, Ottawa Silica Co., Ottawa Ill., has been named as general sales manager of Ottawa Silica and its subsidiaries. **Jerald E. Pixley**, formerly assistant sales manager, is now sales manager, Glass & Ceramic Div. **William H. Woodward**, vice-president of sales, is being retained in an advisory capacity, due to ill health.

Paul L. McCulloch, Jr. . . . vice-president American Brake Shoe Co. has been appointed as group executive of the newly formed industrial castings group composed of four of the company's divisions. He will have overall responsibility for the operations of the American Manganese Steel Div., Electro-Alloys Div., Engineered Castings Div., and National Bearing Div., which operate 15 plants throughout the U. S. McCulloch has been president of the company's Electro-Alloys Div.; succeeding him in this position will be **William D. Raddatz**, who has been a vice-president of the division.

Dr. Guilliam H. Clamer . . . was honored on his 85th birthday by the Brass and Bronze Ingot Institute. He has been responsible for many inventions including the high frequency induction furnace developed with Dr. Edwin Northrup in 1918. This furnace became the basis of an industrial complex of five corporations under the Ajax Electro Thermic Corp., a complex he has headed since 1920. Ajax was acquired by H. Kramer & Co. in 1959. Clamer has served as an AFS National Director, President 1923-24, was awarded the Seaman Gold Medal in 1933 and served as an AFS-T&RI Trustee 1957-58.

Kermit A. Skeie . . . Magnaflux Corp. western region manager, Los Angeles, has been placed in charge of commercial inspection with offices in Chicago. He is succeeded on the west coast by


R. G. Strother


K. A. Skeie


S. C. Wasson


W. H. Hauschildt


D. V. Walker


R. R. Beals

Richard Turner, new Los Angeles branch manager. This is one of three national sales positions replacing functions formerly conducted through regional managers, posts now abolished. **Denis P. Walsh,** midwest region manager, Chicago, becomes manager of distributor and representative sales. **Robert G. Strother,** eastern region manager, New York City, moves to Chicago in charge of field engineering. He is succeeded by **Henry Bogart,** new New York branch manager. **Norm Sonderman** continues in charge of field engineering which involve the sales on government contracts.

Dudley V. Walker . . . vice-president and director of Eastern Malleable Iron Co., and for the last 17 years managing director of its Eberhard Mfg. Div. in Cleveland, retired July 1. His family has been associated with Eastern Malleable and its predecessors for four generations. Walker started with the company in 1919, was assigned to Eberhard as sales manager shortly after its purchase by Eastern Malleable of Naugatuck, Conn., in 1936. He became managing director in 1943.

Ralph R. Beals . . . has joined the sales and marketing staff of Carondelet Foundry Co., St. Louis. He has been with Carondelet for 25 years, chiefly in the production department.

Stowell C. Wasson . . . operating vice-president of National Malleable & Steel Castings Co., Cleveland, has retired to Landrum S. C., after 49 years service with that company. Wasson began his career with National Malleable in 1911 as a purchasing trainee at the company's Indianapolis plant. He was active in the formation of the Central Indiana Chapter while manager of the Indianapolis plant. He served as an AFS National Director 1946-1949, as president of the Foundry Educational Foundation, and was active for many years in the Malleable Founders' Society. Between 1943 and 1954 he was manager of the Cicero and Melrose Park, Ill., plants of National Malleable before succeeding the late Walton L. Woody as operating vice-president in 1954.

Wesley H. Hauschildt . . . is now chief production engineer for aluminum operations in the foundry department of the Dow Metal Products Co., Div. Dow Chemical Co., at the Bay City, Mich., plant. He will have production responsibility for a new Dow product line—aluminum sand and permanent mold castings. Hauschildt comes to Dow Metal Products from American Brake Shoe Co., Mahwah, N. J.

Steve Denkinger . . . formerly sales representative for Shalco Div., National Acme Co., Cleveland, has been appointed sales manager of the newly formed Equipment Div. of Milwaukee Chaplet & Supply Corp.

Carl S. Weyandt . . . president, and one of the founders of Syntron Co., Homer City, Pa., retired April 30 after more than 40 years service. He became vice-president and general manager in 1921 and president in 1937. Weyandt will continue as a member of the board of directors of Syntron and of Link-Belt Co., Chicago, of which Syntron is a subsidiary. **Byron K. Hartman** is now Syntron president. He joined Syntron in 1959 after having been associated with Link-Belt for 21 years.

Russell Franks . . . credited with many major metallurgical developments in stainless and alloy steels during his more than 40 years with Union Carbide Corp., has retired from active service. He was recently manager of Union Carbide Metals Co. Marketing Research Div. and will continue to serve in consulting capacity.

Hermann K. Intemann has been named director of purchases for Union Carbide Corp., **William H. Feathers** has been appointed president of Union Carbide Metals Co., and **James R. Johnstone** has been made president of National Carbon Co. Intemann had been

Circle No. 153, Page 147

president of Union Carbide Metals Co. since 1957. Feathers had been president of National Carbon Co. for about a year and Johnstone had been administrative assistant to Feathers.

Lawrence H. Callahan . . . vice-chairman of the AFS Rochester Chapter and formerly technical advisor, The Anstice Co., is now foundry manager, Rochester Bronze & Aluminum Foundry Co.

Frank H. Dettore . . . vice-president, G. E. Smith, Inc., Pittsburgh, Pa., has been elected as a director. **Paul Barry** has been named as sales and service engineer. He was formerly eastern sales representative for Thiem Products, Inc.

Jerold P. Greco . . . has been promoted from executive vice-president to president of Bigelow-Garvey Lumber Co., Chicago. He has been associated with the firm for 24 years.

Fritz Nussbaum . . . has been advanced to executive vice-president in charge of operations of Apex Smelting Co., Chicago. **William R. Bayer**, secretary and treasurer, has been elected a director. Officers reelected are: **William A. Singer**, chairman; **Louis Lippa**, president; **Charles J. LaFond**, vice-president; **Dwight L. Palmer**, vice-president; **Donald L. Colwell**, vice-president; **Alton J. Peterson**, vice-president; and **William R. Bayer**, secretary and treasurer.

William E. Schrell . . . has joined Crosby Foundry Sales, Rocky River, Ohio, as a sales engineer covering the western half of Ohio.

Joe T. Gilbert . . . formerly with Stockham Valves & Fittings Co., is now associated with M. Kimerling & Sons, Inc., Birmingham, Ala.

Lee P. Burgess . . . has been named as vice-president, Belcher Malleable Iron Co., Easton, Mass. He joined the Belcher organization in 1959 after serving 21 years at the Wire Rope Corp. of America.

Russell A. Ziege . . . formerly with Burnham Pattern, Inc., Milwaukee, has been appointed plant manager in charge of the Milwaukee operations of foundry Specialties Mfg. Co., Chicago.

John M. Patterson . . . formerly sales manager of the Alloy Div., Beryllium Corp., has been advanced to the newly created position of manager, overseas operations. Dale J. Richards, formerly assistant sales manager, has been named manager beryllium alloy sales of the Alloy Div. **Ethan A. Smith, Jr.**, who is associated with the coporations' Nuclear Div., Hazleton, Pa., is now manager, beryllium metal sales, a newly created position.

Dr. Robert I. Jaffee . . . and **George K. Manning,** veteran Battelle Memorial Institute metallurgists, have been named as technical managers in the Department of Metallurgy at the Columbus, Ohio research center.

Verle B. Utzinger . . . formerly superintendent of foundries, Walworth Co., Braintree, Mass., is now assistant plant superintendent in charge of foundry operations, Sloan Valve Co., Chicago.

obituaries

Gordon L. Paul . . . 48, foundry division manager of Brillion Iron Works, Brillion, Wis., died July 29, in Brillion. He started his foundry career as an apprentice with Brown & Sharpe Mfg. Co., Providence, R. I., later becoming a laboratary assistant, metallurgist and assistant superintendent. In 1953 he became general manager of Sterling Foundry Co., Wellington, Ohio, and in 1958, works manager of Hansell-Elcock Co., Chicago. In January, 1960 he was advanced to manager of the foundry division and shortly afterwards became foundry division manager of Brillion Iron Works. Paul had been a director in both the AFS Northeastern Ohio and Chicago Chapters.

Henry F. Wardwell, 83, president of Burnside Steel Foundry Co., Chicago, died Aug. 1 in his home. He founded Burnside Steel in 1916. His son, Henry Wardwell II, is vice-president of the company.

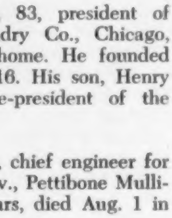
William F. Goetz, 61, chief engineer for Beardsley & Piper Div., Pettibone Mulliken Corp., for 25 years, died Aug. 1 in Chicago.

Eugene H. Bird, 67, president of Eastern Gas and Fuel Associates, Boston, long prominent in the coal, coke, gas, and associated industries, died July 19, while convalescing from an operation. He has been associated with Eastern Gas since its formation in 1929 and had been president since 1955.

J. L. Thies, president, Fenton Foundry Supply Co., Dayton, Ohio, died May 15.

John P. DeNoto, foreman, C/R Dept., Casting Service Corp., Bridgeham, Mich., died May 10.

Clifford M. Cornell, 68, secretary-treasurer of Cleveland Flux Co., Cleveland, died Aug. 3. He was injured July 21 in a traffic accident in Alliance, Ohio. Cornell had been with Cleveland Flux since it was founded by his father in 1918.



C. M. Cornell

He was a director of Clyde Cutlery Co., Clyde, Ohio; Morgan Engineering Co., Alliance, Ohio; and Prestole Corp., Toledo, Ohio.

Circle No. 161, Page 147

New Products and Processes

Build an idea file for improvement and profit. Circle numbers on literature request card, page 147, for manufacturers' information.

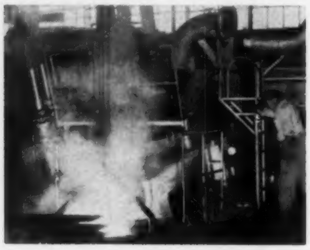
Adding Mischmetal Pellets May Improve Fluidity

Mischmetal pellet additions reportedly improve fluidity for better castability for various section thicknesses of carbon steel, low-alloy steel, cobalt-base alloys, stainless steels, hot work tool steels, nickel-base alloys, aluminum alloys, and copper-base alloys. Samples of pellets are available. Cerium Metals & Alloys Div., Ronson Metals Corp.

For More Information, Circle No. 1, Page 147

Alloy Used in Bar and Plate Form Available for Casting Production

Patented constructional alloy license has been granted to Alloy Steel & Metals Co., Los Angeles for casting production. The alloy reportedly has a high fluidity, permitting pouring at



a relatively low temperature. It has been used in plate and bar form to meet a wide-variety of applications calling for a combination of strength, toughness, field weldability, and resistance to wear and corrosion. U. S. Steel Corp.

For More Information, Circle No. 2, Page 147

Ferro Alloy Briquettes Feature Coding by Size and Color

Each ferro-alloy briquette contains a precise amount of given alloy, notched to permit addition of half briquettes, and a special binder offering protection against losses in the oxidizing atmosphere above the cupola melting zone. In the melting zone, the alloy goes into the bath and the binder into the slag. Ohio Ferro-Alloys Corp.

For More Information, Circle No. 3, Page 147

Asbestos Safety Clothing Sheds Molten Metal up to 3000 Degrees

Asbestos safety clothing sheds molten metal at 3000 F. without deterioration, loss of resiliency or discoloring of the inner side. The specially wov-

en fabric reportedly offers 40-50 per cent greater abrasion resistance than ordinary asbestos and has nearly double the tensile strengths of fabrics twice its weight and thickness. American Optical Co.

For More Information, Circle No. 4, Page 147

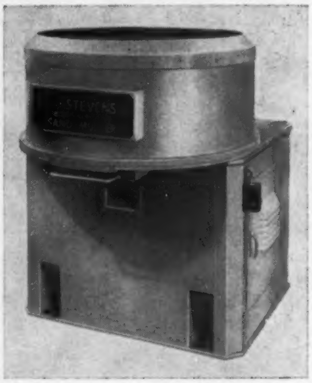
Crusher Handles Friable Material Without Damage or Slowing Down

Crusher handles friable material containing non-crushable matter without damage or slowing down. Ideal for breaking up material which has tendency to cake or become encrusted in processing Tramp metal passes through without damaging machine or slowing it down. An air-cushioned breaker bar serves as a release mechanism for foreign bodies in the material and absorbs shock overloads to prevent strain on wearing part. Individual teeth replaced readily. C. O. Bartlett & Snow Co.

For More Information, Circle No. 5, Page 147

400-Pound Muller Batch Mixes Sand and Various Binder Types

Muller with 400 pound capacity, batch mixes sand with CO_2 binder, air-setting binders, resin binder, core



oil and other types of binders used in sand core and mold production. Unit stands four feet high and occupies only seven square feet of space. Frederic B. Stevens, Inc.

For More Information, Circle No. 6, Page 147

Heated Manifolds Prevent Freeze Ups in CO_2 Coremaking Operations

Electrically-heated CO_2 manifolds prevent regulator freeze ups while cutting gas consumption during CO_2 core making and welding operations.

Manifolds are self-contained, one-piece units designed for any standard regulators, and come equipped with all necessary fittings, gaskets and electrical wiring. Heating is by an electrical element built into the manifold. World Electric Co.

For More Information, Circle No. 7, Page 147

Direct-Reading Moisture Gage

Moisture gage furnishes relative percentage of moisture in foundry

sands. Direct-reading instrument is in the 0 to 10 per cent range and available in 0 to 100 per cent range. Henry Francis Parks Laboratory.

For More Information, Circle No. 8, Page 147

Tractor Shovels Solve Many Handling Operations in Malleable Foundry

Two tractor-shovels with an operating capacity of 2500 pounds have solved many handling operations at Lancaster Malleable Casting Co., Lancaster, Pa. Units are used on the night shift in molding operations, han-

dling approximately 90 tons of sand four times during stockpiling, mixing, feeding the separator, and transporting prepared sand to 58 molding stations. The day shift uses one of these trucks for slag dump work and unloading boxcars of sand. Frank G. Hough Co.

For More Information, Circle No. 9, Page 147

Vibrating Mechanisms Allow Large Shakeouts for Jobbing Foundries

Heavy duty shakeouts for large jobbing foundries have vibrating mechanisms permitting sizes up to 18x20 feet in size and 150 tons in capacity. Vibrators reduce the amount

of mechanical and drive components to be maintained and eliminate most of the operating problems of multiple units such as load distribution and scrap handling, according to manufacturer. Hewitt-Robins, Inc.

For More Information, Circle No. 10, Page 147

Heat Treating Furnace Maintains Temperature Regardless of Load

Uniform furnace temperature for heat treating processes, regardless of loading, reportedly is obtained with gas burner which lowers gas intake while maintaining an excess air rate. Provision is also made for a flame monitoring device to assure flame safety. Either an interrupted or constant pilot may be used. Burner available with air pipe sizes from 3/4 to 1-1/2 in. North American Mfg. Co.

For More Information, Circle No. 11, Page 147

Heavy-Duty Cutting Torch Permits Gradual Introduction of Oxygen

Heavy-duty cutting torch cuts steel up to 24-in. thick. Features oxygen control valve permitting gradual introduction of cutting oxygen reducing slag spray and facilitates control in such operations as piercing, rivet washing and heavy cutting. Equipped with over-or-under cutting lever easily reversed for operator preference. Smith Welding Corp.

For More Information, Circle No. 12, Page 147

Coiled Nylon Air Hose Eliminates Hazards, Inconveniences

Coiled nylon air hose which stretches and retracts like a telephone cord, eliminates hazards and inconvenienc-

es caused by straight air hoses lying on the floor. In its retracted position, the air hose coils to only a few inches, is always out of the way, and does not require expensive recoil mechanisms. Nycoil Co.

For More Information, Circle No. 13, Page 147

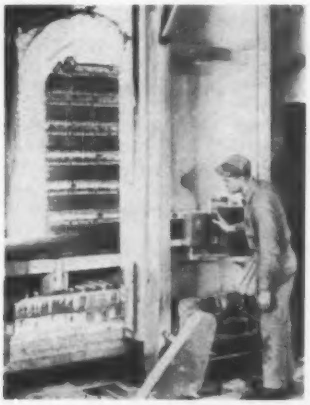
Fused Silica Refractory Resists Expansion, Thermal Shock

Fused silica refractory is being used for foundry permanent molds, pouring spouts, crucibles, one-piece furnace hearths, and in industrial furnace kiln construction. Expansion and thermal shock have practically no effect at temperatures from near absolute zero to 3100 F. Ceramic bodies are easily molded to specifications in production runs in almost any length and size. Pieces too large to ship may be cast and fired in place. May be molded without joints. Separate large pieces may be joined, the joints concealed, before or after firing, and re-fired in place. Glasrock Products, Inc.

For More Information, Circle No. 14, Page 147

Electric Heat Car Bottom Furnace Features Two Heating Rates

Special connections for either fast or slow heating rates are featured in an electric heat car bottom furnace. Heating elements are mounted in the side walls and under the hearth as well as on the rearwall, and the door.



For fast heating, elements are delta connected, and for slow heating, the elements are star connected. Maximum temperature range is 2000 F. The availability of two heating features offers versatility to jobbing operations. Waltz Furnace Co.

For More Information, Circle No. 15, Page 147

Dust-Free Wood Flour Available

Dust-free wood flour is now available, according to processor. Has identical properties with its regular wood flour except that it is free from diffusion when used. Samples available. Penn-Rillton Co.

For More Information, Circle No. 16, Page 147

Introduce Epoxy Resin Line for Use with Molds and Patterns

New epoxy resins have been introduced for foundry and tooling industries. One is formulated for making epoxy molds and patterns especially for small items where intricate design and surface dimensions are important. Second is for making molds for casting epoxy duplications. Another has been formulated for use with epoxy molds and patterns. A layup formula has been developed for use with epoxy molds and patterns.

For More Information, Circle No. 17, Page 147

For The Asking

Build an idea file for improvement and profit. Circle numbers on literature request card, page 147, for manufacturers' publications.

Decimal equivalent . . . card covers range from 1/64-inch to one inch. Newton-New Haven Co.

For Your Copy, Circle No. 25, Page 147

Green sand . . . molding can produce precision and tolerance, according to newsletter which is yours for the asking. American Colloid Co.

For Your Copy, Circle No. 26, Page 147

Portable testing kits . . . for non-destructive testing of castings are available in four models, shown in brochure. Magnaflux Corp.

For Your Copy, Circle No. 27, Page 147

Continuous crushing . . . and de-oiling of metal chips and turnings, automatically, is subject of new 12-page brochure describing metal chip handling systems. Link-Belt Co.

For Your Copy, Circle No. 28, Page 147

Utility tractor . . . line and matched equipment detailed in new 12-page catalog. Allis-Chalmers.

For Your Copy, Circle No. 29, Page 147

Reclamation . . . of sand presents problems which are discussed in booklet. Lists cost savings to be expected by the average foundry. Beardsley & Piper Div., Pettibone Mulliken Corp.

For Your Copy, Circle No. 30, Page 147

Conveyors . . . for materials handling in foundries presented in brochure. Logan Co.

For Your Copy, Circle No. 31, Page 147

Metallurgical laboratory . . . services offered in new brochure illustrating testing and analysis facilities. Includes table of international atomic weights. Charles C. Kawin Co.

For Your Copy, Circle No. 32, Page 147

Molds on conveyors . . . Request this bulletin to see how 10,000-pound molds ride railroad-type conveyors from pouring to shakeout without using over-head cranes. Nomad Equipment Corp.

For Your Copy, Circle No. 33, Page 147

Tractors and equipment . . . for industrial use presented in brochure. Includes tractor-shovels, power-angling dozers, power-tilting bulldozers, wheel loaders, fork lift, and interchangeable attachments. J. I. Case Co.

For Your Copy, Circle No. 34, Page 147

Aluminum bearings . . . and bushings discussed in 90-page study including case histories, engineering and test data. Aluminum Co. of America.

For Your Copy, Circle No. 35, Page 147

Microstructure . . . of gray iron castings illustrated in 12-page booklet showing micrographs of castings with from 31,500 to 63,000 psi. To obtain, use circle number. Herbert A. Reece & Associates.

For Your Copy, Circle No. 36, Page 147

Machining manual . . . 22-pages, is a guide for machine feeds and speed, includes quantity-weight slide rule calculator, and other basic information. Kaiser Aluminum & Chemical Sales, Inc.

For Your Copy, Circle No. 37, Page 147

Aluminum castings . . . producers can learn how to achieve greater accuracy in estimating weights of their castings with this booklet. Aluminum Foundry Div., Aluminum Association.

For Your Copy, Circle No. 38, Page 147

Casting aluminum . . . is subject of new technical handbook available to you. Covers various casting processes suitable for aluminum. Reynolds Metals Co.

For Your Copy, Circle No. 39, Page 147

Circular slide rule . . . is yours for the asking. Includes hairline attachment for accuracy. General Industrial Co.

For Your Copy, Circle No. 40, Page 147

Basic guide . . . for ferrous metallurgy available in wall chart form. Offers relationship of per cent carbon in steel to grain size, microstructure, and fabrication techniques through temperatures of from -300 F to 2900 F. Tempil Corp.

For Your Copy, Circle No. 41, Page 147

Cupola emission . . . control features new approach guaranteed to remove down to 0.35 pounds per 1000 pounds of gases. Use the circle number below for brochure. Claude B. Schneible Co.

For Your Copy, Circle No. 42, Page 147

New dry core binder . . . combines a reported unmatched combination of properties with reduction in baking time from 30 to 50 per cent. Ask for brochure. Corn Products Sales Co.

For Your Copy, Circle No. 43, Page 147

Master model . . . duplicating process claimed to be greatest advance in this technique in 50 years. Brochure explains the use of nickel carbonyl in this process, and points out characteristics and properties. The Budd Co., Budd Carbonyl Metal Products.

For Your Copy, Circle No. 44, Page 147

Pattern millers . . . for pattern and core box work shown in 38-page brochure. Many applications portrayed. Wadkin Ltd.

For Your Copy, Circle No. 45, Page 147

Magnesium finishing . . . and its use in overcoming corrosion discussed in bulletin. Dow Metal Products Co.

For Your Copy, Circle No. 46, Page 147

Direct-wire TV . . . as a business tool is explained in booklet which states that system may be employed with minimum investment of 595 dollars. Sylvania Electric Products Inc.

For Your Copy, Circle No. 47, Page 147

Feeders and rotary valves . . . designed to handle large variety of dry pulverized and granular materials. Read about complete line in 8-page bulletin. Fuller Co.

For Your Copy, Circle No. 48, Page 147

Fork truck operation . . . portrayed in color, sound slide film. Models of 4000 and 6000-pound capacity are included. Viewing time, 20 minutes: free loan. Industrial Truck Div., Clark Equipment Co.

For Your Copy, Circle No. 49, Page 147

1959 Index . . . to MODERN CASTINGS is available. American Foundrymen's Society.

For Your Copy, Circle No. 50, Page 147

Aluminum alloys . . . brochure offers guide for selection of casting alloys; covers physical properties, fabrication characteristics, and economic advantages of company's alloys. Olin Mathieson Chemical Corp.

For Your Copy, Circle No. 51, Page 147

CO_2 . . . and its value in the foundry industry featured in new 24-p booklet. Pure Carbonic Co.

For Your Copy, Circle No. 52, Page 147

Effect of tin . . . on flake and nodular graphite cast irons discussed in reprint from AFS TRANSACTIONS. American Foundrymen's Society.

For Your Copy, Circle No. 53, Page 147

Tooling plastics . . . technical bulletin outlines procedures for constructing core boxes, patterns, matchplates, other foundry components. Furane Plastics, Inc.

For Your Copy, Circle No. 54, Page 147

Table room cleaning . . . of castings featured in 12-page brochure describing blast cleaning unit designed to han-

Advertised Products September—1960

Yours . . . For Advancing Metalcasting

Are you looking for information on any of the subjects listed in the left hand column? Our MODERN CASTINGS advertisers have carefully prepared important material on each of these topics to help advance your metalcasting practices. You will find it on the page shown opposite the subject of your interest.

Technical literature is also available on these and many other subjects. Just circle the correct number on the card below that corresponds to the Circle No. shown with each ad and new products items in "New Products and Processes" and "For the Asking" departments.

Here's your opportunity to build a valuable reference file of new products, processes, and techniques.

SEPTEMBER 1960–2

Valid through Dec. 1960

NEW EQUIPMENT AND MATERIALS

1	13	25	37	49	61	73	85	97	109
2	14	26	38	50	62	74	86	98	110
3	15	27	39	51	63	75	87	99	111
4	16	28	40	52	64	76	88	100	112
5	17	29	41	53	65	77	89	101	113
6	18	30	42	54	66	78	90	102	114
7	19	31	43	55	67	79	91	103	115
8	20	32	44	56	68	80	92	104	116
9	21	33	45	57	69	81	93	105	117
10	22	34	46	58	70	82	94	106	118
11	23	35	47	59	71	83	95	107	119
12	24	36	48	60	72	84	96	108	120

☐ I wish to subscribe to MODERN CASTINGS

ADVERTISED PRODUCTS

121	133	145	157	169	181	193	205
122	134	146	158	170	182	194	206
123	135	147	159	171	183	195	207
124	136	148	160	172	184	196	208
125	137	149	161	173	185	197	209
126	138	150	162	174	186	198	210
127	139	151	163	175	187	199	211
128	140	152	164	176	188	200	212
129	141	153	165	177	189	201	213
130	142	154	166	178	190	202	214
131	143	155	167	179	191	203	215
132	144	156	168	180	192	204	216

PLEASE PRINT

Name________

Position________

Company________

Address________

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 83, Sec. 34.9 P. L. & R.
DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf and Wolf Rds.
Des Plaines, Ill.

Yours . . . For Advancing Metalcasting

Are you looking for information on any of the subjects listed in the right hand column? Our MODERN CASTINGS advertisers have carefully prepared important material on each of these topics to help advance your metalcasting practices. You will find it on the page shown opposite the subject of your interest.

Technical literature is also available on these and many other subjects. Just circle the correct number on the card below that corresponds to the Circle No. shown with each ad and new products items in "New Products and Processes" and "For the Asking" departments.

Here's your opportunity to build a valuable reference file of new products, processes, and techniques.

PLEASE PRINT

Name

Position

Company

Address

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 83, Sec. 34.9 P. L. & R.
DES PLAINES, ILL.

Reader Service Dept.

MODERN CASTINGS

Golf and Wolf Rds.

Des Plaines, Ill.

SEPTEMBER 1960–2

Valid through Dec. 1960

NEW EQUIPMENT AND MATERIALS

1	13	25	37	49	61	73	85	97	109
2	14	26	38	50	62	74	86	98	110
3	15	27	39	51	63	75	87	99	111
4	16	28	40	52	64	76	88	100	112
5	17	29	41	53	65	77	89	101	113
6	18	30	42	54	66	78	90	102	114
7	19	31	43	55	67	79	91	103	115
8	20	32	44	56	68	80	92	104	116
9	21	33	45	57	69	81	93	105	117
10	22	34	46	58	70	82	94	106	118
11	23	35	47	59	71	83	95	107	119
12	24	36	48	60	72	84	96	108	120

☐ **I wish to subscribe to MODERN CASTINGS**

ADVERTISED PRODUCTS

121	133	145	157	169	181	193	205
122	134	146	158	170	182	194	206
123	135	147	159	171	183	195	207
124	136	148	160	172	184	196	208
125	137	149	161	173	185	197	209
126	138	150	162	174	186	198	210
127	139	151	163	175	187	199	211
128	140	152	164	176	188	200	212
129	141	153	165	177	189	201	213
130	142	154	166	178	190	202	214
131	143	155	167	179	191	203	215
132	144	156	168	180	192	204	216

Advertised Products September—1960

dle large, heavy pieces up to 10-foot diameter, 3-1/2 feet high, and weighing 10,000 pounds. Pangborn Corp.

For Your Copy, Circle No. 55, Page 147

New CO_2 process booklet . . . now available; discusses chemical reaction, selection of sands, and sand reclamation. Cardox Div., Chemetron Corp.

For Your Copy, Circle No. 56, Page 147

Powered platform trucks . . . and plant conditions and operations where costs can be reduced by using them is subject of brochure. Prime-Mover Co.

For Your Copy, Circle No. 57, Page 147

Leasing tools . . . through this plan features reported low bank rate financing and no security deposits or down payment. Bulletin explains 5-year leasing plan. American Tool Works Co.

For Your Copy, Circle No. 58, Page 147

Silicate-CO_2 . . . process discussed in house organ. Recent process for binding core and mold sands. Philadelphia Quartz Co.

For Your Copy, Circle No. 59, Page 147

Storage racking . . . selection and pitfalls to avoid in buying this equipment is subject of 26-page booklet. Paltier Corp.

For Your Copy, Circle No. 60, Page 147

Radiation . . . articles compose a non-technical series on radiation designed as an educational tool for personnel engaged in radiation work. R. S. Landauer, Jr. & Co.

For Your Copy, Circle No. 61, Page 147

Grinding and finishing . . . cost check service reviews company's operational procedures, and recommends changes for more efficient operation. Use the circle number below for complete information. Minnesota Mining & Mfg. Co.

For Your Copy, Circle No. 62, Page 147

Mold release oils . . . for zinc and aluminum die casting described in new technical bulletin. Sun Oil Co.

For Your Copy, Circle No. 63, Page 147

Mold production . . . increased by more than 2 to 1 by new hydra-mold unit, according to case history presented in 12-page brochure. Beardsley & Piper Div., Pettibone Mulliken Corp.

For Your Copy, Circle No. 64, Page 147

Arc welding guide . . . contains 80 pages of arc welding information including five essentials for proper welding procedures. Hobart Brothers Co.

For Your Copy, Circle No. 65, Page 147

Hot blast . . . cupola air pre-heating reportedly offers important economic and quality control advantages for foundries. Read about it in free bulletin. Brown Metals Inc.

For Your Copy, Circle No. 98, Page 147

Measures up to 7600 F . . . in plant or laboratory. New line of pyrometers described in new 6-page data sheet. Leeds & Northrup Co.

For Your Copy, Circle No. 66, Page 147

"Hot oil" . . . type of quenching medium covered in bulletin which cites typical characteristics of the new product and outlines benefits. Sun Oil Co.

For Your Copy, Circle No. 67, Page 147

Heating elements . . . in controlled atmosphere furnaces are now being manufactured from a new modified nickel-chromium resistance alloy, discussed in 8-page bulletin. Hoskins Mfg. Co.

For Your Copy, Circle No. 68, Page 147

Vacuum impregnation . . . the process of filling voids in porous materials or assemblies with a desired impregnant after air and moisture have been removed, discussed in new brochure. F. J. Stokes Corp.

For Your Copy, Circle No. 69, Page 147

Ten-pound foundry pigs . . . combine manganese, iron, carbon (combined and graphitic), silicon, phosphorus, and sulphur to offer improved quality in your castings, according to manufacturer. Ask for folder. New Jersey Zinc Co.

For Your Copy, Circle No. 70, Page 147

Heat resistant alloy . . . designed to perform in the 1800-2300 F. range for static, centrifugal, and shell-molded cast-

ings, discussed in folder. Electro-Alloys Div., American Brake Shoe Co.

For Your Copy, Circle No. 71, Page 147

All metal conveyor . . . designed for reduced maintenance. Request brochure for foundry applications. M-H Standard Corp.

For Your Copy, Circle No. 72, Page 147

Barrel finishing . . . media, compounds, machines, and equipment presented in catalog. Carborundum Co., Electro Minerals Div.

For Your Copy, Circle No. 73, Page 147

Automatic scrap handling . . . systems described in bulletin featuring four case histories. Gifford-Wood Co.

For Your Copy, Circle No. 74, Page 147

Co_2 . . . production and use in industry is subject of 24-page bulletin. Pure Carbonic Co.

For Your Copy, Circle No. 75, Page 147

Thermocouple wire . . . and extension wire, bare and insulated, are covered in new catalog. Minneapolis-Honeywell Regulator Co.

For Your Copy, Circle No. 76, Page 147

Binders and additives . . . for core and molding sands fully described in new 12-page booklet. Corn Products Sales Co.

For Your Copy, Circle No. 77, Page 147

Zinc . . . metals and alloys fully discussed and specified in 38-page booklet. New Jersey Zinc Co.

For Your Copy, Circle No. 78, Page 147

Foundry sand additives . . . presented in series of advertisements which are bound in booklet form. Eastern Clay Products Dept., International Minerals & Chemical Corp.

For Your Copy, Circle No. 79, Page 147

Resin binder . . . for use in dry sand molding and core making said to eliminate 25 per cent of operations normally performed in an oil-sand binding system. Request bulletin 700. Archer-Daniels-Midland Co., Federal Foundry Supply Div.

For Your Copy, Circle No. 80, Page 147

Tumbling-blasting . . . combined to offer increased efficiency in castings cleaning in company's new unit. Reported to save cleaning time, wearables, abrasive, maintenance, and man-hours. Brochure delineates features and specifications. Wheelabrator Corp.

For Your Copy, Circle No. 81, Page 147

New furnace . . . is pit type, air draw gas-fired or electrically-heated heat treating furnace. Designed to provide accuracy in lower range heat treating. Request bulletin. Hevi-Duty Electric Co.

For Your Copy, Circle No. 82, Page 147

Mechanized sand system . . . for the small foundry delivers molding sand direct to molder. May be charged at floor level, by belt, front end loader, or connected directly to bottom discharge muller. Request bulletin. National Engineering Co.

For Your Copy, Circle No. 83, Page 147

Sand reclamation . . . unit can reportedly reduce new sand costs up to 80 per cent. Learn about this new equipment and what 60 foundries say about it in company's brochure. National Engineering Co.

For Your Copy, Circle No. 84, Page 147

Steel strapping . . . pneumatic stretcher for applying flat steel strapping from vibrated wound coils is shown in bulletin. A. J. Gerrard & Co.

For Your Copy, Circle No. 85, Page 147

Combustion equipment . . . catalog gives complete specifications for company's line of burners, mixers, pilots, regulators, blowers, valves, and accessories. Bryant Industrial Products Corp.

For Your Copy, Circle No. 86, Page 147

Power tools . . . covered in new mailer catalog. Skil Corp.

For Your Copy, Circle No. 87, Page 147

Resin coated sand . . . for shell cores and shell molds described in new brochure. Faskure Coated Sand Div., Aurora Metal Co.

For Your Copy, Circle No. 88, Page 147

Shell investment . . . casting technique utilizes a highly refractory, relatively thin coating of ceramic around a disposable pattern as the molding medium. Request brochure. Engineered Precision Casting Co.

For Your Copy, Circle No. 89, Page 147

Parting compounds . . . and liquids, release agents, silicones, shell molding, and core release agents described in 12-page catalog. Hill & Griffith Co.

For Your Copy, Circle No. 90, Page 147

Chemical milling . . . process discussed in free reprint covering processing of steel and other metals on mass-production basis. Chemical Contour Corp.

For Your Copy, Circle No. 91, Page 147

Thermocouples . . . of hard-pack, small-diameter, mineral-insulated design are presented in new catalog. Minneapolis-Honeywell Regulator Co.

For Your Copy, Circle No. 92, Page 147

Tungsten-inert-gas welding . . . process illustrated in newly revised 24-page catalog featuring complete line of manual, semi-automatic, and automatic equipment. Air Reduction Sales Co.

For Your Copy, Circle No. 93, Page 147

Foundry epoxy use . . . case histories brochure discusses 10 applications said to enable savings up to 60 per cent. Furane Plastics Inc.

For Your Copy, Circle No. 94, Page 147

Instruction manual . . . for carbon arc welding has recently been released. Manual covers use of twin electrode carbon arc welding torch. Arcair Co.

For Your Copy, Circle No. 95, Page 147

New Books for You . . .

Transactions of the Vacuum Metallurgy Conference . . . Rointan F. Bunshah, 212 pages. New York University Press. 1960. Presents results of the 1959 meeting on vacuum metallurgy held at New York University under sponsorship of the university's department of metallurgical engineering in cooperation with the Offices of Special Services to Business and Industry. Book is divided into six sections dealing with: vacuum arc melting and casting; vacuum investment casting; vacuum induction melting; vacuum degassing; electron-beam techniques in vacuum metallurgy; and applications of vacuum metallurgy. Authors are from the United States, England, and West Germany.

1959 A.S.T.M. Proceedings, vol. 59 . . . 1424 pages. American Society for Testing Materials, 1916 Race St., Philadelphia. Records the technical accomplishments of the year, including reports and papers, together with discussions, accepted for the Proceedings. Includes summary of the 62d annual meeting, summary of the Third Pacific Area National Meeting, listing by title and author the programs for each session. There are 71 reports of technical committees and 44 technical papers and discussions. In addition to papers and reports, there are listed all symposia and other special sessions published separately as special technical publications and all papers published in the A.S.T.M. bulletin.

The Engineering Index, 75th edition . . . 1532 pages. Engineering Index, Inc., 29 West 39th St., New York. 1959. Contains over 39,100 annotations of articles reviewed in 1700 publications of engineering, scientific, and technical societies; engineering and industrials periodicals, and publications of government bureaus; engineering experimental stations, universities, and other research organizations. Index is arranged under 249 field of interest divisions of engineering. Twelve pages are devoted to a list of technical publications received and reviewed. Ninety-six pages contain an index of authors of articles reviewed.

Gas Shielded-Arc Welding of Aluminum and Aluminum Alloy Pipe . . . American Welding Society, 33 W. 39th St., New York. 40 pages. Booklet has been prepared by the A.W.S. committee on piping and tubing, covers all phases of aluminum pipe welding from processes and machine settings, to welding techniques and heat treatment. A conversion table presents the A.S.T.M. alloy designation and the corresponding commercial alloy number which has been adopted by the Aluminum Association. Another table recommends the filler metals which should be used for welding different combinations of aluminum alloys.

Techniques of Plant Maintenance & Engineering—1960 . . . Clapp & Poliak, Inc., 341 Madison Ave., New York. 341 pages. The volume is a report on the plant maintenance and engineering conference held in Philadelphia. The book contains 34 papers presented at the 1960 conference with the text of all discussions, comments, questions asked from the floor, and answers from speakers and panel members.

Alloy Casters Name J. D. Hagans

J. D. Hagans, sales manager, Ohio Steel Foundry Co., Springfield, Ohio, has been elected as president of Alloy Casting Institute for the 1960-61 fiscal year. He succeeds J. B. Dear, sales manager, Duraloy Co., Scottdale, Pa.

Re-elected to the office of vice-president was J. S. Wooters, General Alloys Co., Boston. E. A. Schoefer, Garden City, N.Y., was re-elected as executive vice-president and treasurer.

Two new members were elected to the board of directors. They are: J. K. Louden, Lebanon Steel Foundry, Lebanon, Pa., and J. W. MacKay, American Cast Iron Pipe Co., Birmingham, Ala.

Pick Jenni As Steel Lecturer

Steel Founders' Society of America has selected Clyde B. Jenni, director of research and chief metallurgist of the Eddystone, Pa., plant of General Steel Castings Corp., to deliver the society's exchange lecture before the British Steel Castings Research Association in England this fall.

Jenni will deliver his lecture on "Technical Control in Steel Foundries in North America" in Harrogate, England, Oct. 20.

The exchange with the British association sends a leading U.S. steel castings technical man to Britain every other year.

Classified Advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 35c per word, 30 words minimum, prepaid.
Positions Wanted . . 10c per word, 30 words minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 words.
Display Classified . . Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

HELP WANTED

PLANT ENGINEERS
Experienced on layout of all types of foundry equipment, material handling and material flows. Send complete details on work history, education and family status. Include recent photograph. All replies confidential. Box F-140, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

FOUNDRY METALLURGIST
$10,000. to $12,000.
To start as No. 2 man and in short time advance to Chief Metallurgist for company that places a high value on engineering proficiency. Client will assume all expenses.
Contact: Bill Newell
MONARCH PERSONNEL
28 East Jackson Blvd., Chicago 4, Illinois

MANAGER-SUPERINTENDENT — Mid-west non-ferrous foundry, over $1,000,000 annual sales. Floor and production molding in sand, aluminum permanent mold and heat-treating. Position backed by staff for departmental budget, quality, metallurgical control, methods, standards. Young, aggressive management planning for growth. State experience, qualifications, salary. **Box H-114, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

ASSISTANT FOREMEN — Large Northern Illinois manufacturing company has openings for assistant foremen in their gray iron foundry. Must have high school education or equivalent. Maximum 45 years of age with minimum of 5 years' experience in supervision with 3 years of this in foundry. This is an excellent opportunity for men with potential to advance. Please send complete resume of education, experience, and salary requirements to **Box I-100, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

WANTED-FOUNDRY FOREMAN— for gray and ductile department producing castings in sand and shell. Send detailed resume including salary requirement. **Box I-102, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

GENERAL SUPERINTENDENT- For malleable iron foundry. Applicant must have had experience in production shop. Metallurgical background desirable. Please state age and experience in reply. Must be familiar with malleable iron gating, molding technique, etc. **Box I-101, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

GOOD FOUNDRYMEN
when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.
Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.
For action contact: John Cope
DRAKE PERSONNEL, INC.
29 E. Madison St., Chicago 2, Illinois
Financial 6-8700

NON-FERROUS FOUNDRY SUPERINTENDENT—A good aggressive, production-minded man (preferably engineer) with proven Supervisory experience, required for ultra modern brass small casting captive foundry, producing wide variation repetitive pressure castings. Position backed by staff for quality, methods, budgeting, production control, maintenance, etc. Equipment includes induction melting, automated and standard mechanized production lines. Location, Ontario, Canada. Applicants should write in confidence, enclosing resume, references and salary expected. **Box I-104, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

POSITIONS WANTED

FOUNDRYMAN—Ten years supervisory experience in ferrous and non-ferrous foundry industry. Technical background in metallurgy, chemistry, sand technology, and quality control. Desire technical or sales and service position. Detailed resume on request. **Box G-107, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

STEEL METALLURGIST—experienced in casting design, gating, risering, alloy, carbon and stainless, arc and induction melting, processing, heat treatments, and quality control. Seeks more challenging position. **Box I-103, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

ENGINEERING SERVICES

EARL E. WOODLIFF
Foundry Sand Engineer
Consulting . . . Testing
14611 Fenkell (5-Mile Rd.)
Detroit 27, Michigan
Res. Phone VErmont 5-8724

FOUNDRY CONSULTANT — NON-FERROUS Sand casting — permanent mold casting — centrifugal casting — in aluminum — brasses — bronzes — 30% leaded bronze — aircraft quality bearings and castings — **ED JENKINS, West Palm Beach, Florida — PHONE: Temple 2-8685.**

FOR SALE

MEASURE MOLDING SAND MOISTURE
Quickly & Efficiently With The Model 102 MOISTURE GAGE Direct Reading. Latest Electronic Design. Battery Operated. Highest Possible Sensitivity.
Descriptive Literature FREE!
HENRY FRANCIS PARKS LABORATORY
(Established 1933)
7544 23rd., N.E.
Seattle 15, Washington

ONE MODEL 3F SIMPSON MIX-MULLER—60 cu. ft. batch, used four years, excellent condition. **Address Box H-109, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

ONE MODEL 3 UNIT DRIVE SIMPSON MULLER—with Bucket Loader, Double Discharge Hoppers, Mill Belt, Bucket Elevator, National System Aerator, 14-ft. long Prepared Sand Conveyor, 50 ton Sand Storage Bin. All in good condition. **Address Box H-110, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

REAL ESTATE FOR SALE

FOUNDRY BUILDING
5331 West 66th Street, Chicago, Ill.
28,230 square feet

Office—900 square feet.
Manufacturing area—24,630 square feet—partly sprinklered—200 kw. 120-240 volt power—concrete floor—switchtrack.
Storage and Shop area—2,700 square feet—all sprinklered.
Land—1.987 acres—fenced.
Possession—immediate.
Price—$140,000.00

Scribner & Co., exclusive agents
38 South Dearborn Street
Chicago 3, Illinois CEntral 6-4204

WANTED TO BUY

BACK VOLUMES — Wanted to buy for cash of foundrymen, TRANSACTIONS American Foundrymen's Society and other scientific technical Journals. **Walter J. Johnson, Inc., 111 Fifth Avenue, New York 3, N. Y.**

FREE SERVICE

NEW SERVICE
MODERN CASTINGS announces a new service available to all members of the American Foundrymen's Society. Any member seeking employment in the metal-castings business may place one classified ad of 40 words in the "Positions Wanted" column, FREE OF CHARGE.
Inquiries will be kept confidential if requested. Ads may be repeated in following issues at regular classified rates. Send ads to **MODERN CASTINGS, Classified Advertising Dept., Golf and Wolf Rds., Des Plaines, Ill.**

Advertisers This Issue

Future Meetings and Exhibits

Sept. 6-16 . . National Machine Tool Builders' Association, Machine Tool Exposition. International Amphitheatre, Chicago.

Sept. 12-13 . . Material Handling Institute, Fall Meeting. Cavalier Club, Virginia Beach, Va.

Sept. 14-15 . . American Die Casting Institute, Annual Meeting. Edgewater Beach Hotel, Chicago.

Sept. 15-16 . . Engineering Management Conference. Morrison Hotel, Chicago.

Sept. 18-20 . . Steel Founders' Society of America, Fall Meeting. The Homestead, Hot Springs, Va.

Sept. 19-23 . . Material Handling Equipment Distributors Association, Foundry Materials Handling Course. MHEDA National Training Center, Newport, R. I.

Sept. 19-24 . . International Foundry Congress. Zurich, Switzerland.

Sept. 22-23 . . National Foundry Association, Annual Meeting. Edgewater Beach Hotel, Chicago.

Sept. 26-29 . . American Welding Society, Fall Meeting. Penn-Sheraton Hotel, Pittsburgh, Pa.

Sept. 26-30 . . Instrument Society of America, International Conference & Exhibit and Annual Meeting. New York.

Sept. 27 . . American Management Association, Annual Meeting. Hotel Astor, New York.

Sept. 27-30 . . Association of Iron and Steel Engineers, Annual Convention & Exposition. Public Auditorium, Cleveland.

Oct. 12 . . Cast Bronze Bearing Institute, Annual Meeting. Grove Park Inn, Asheville, N. C.

Oct. 12-14 . . Gray Iron Founders' Society, Annual Meeting. Netherland-Hilton Hotel, Cincinnati.

Oct. 13-15 . . Non-Ferrous Founders' Society, Annual Meeting. Grove Park Inn, Asheville, N. C.

Oct. 14-15 . . AFS New England Regional Foundry Conference. Massachusetts Institute of Technology, Cambridge, Mass.

Oct. 17-18 . . Magnesium Association, Annual Convention. Pick Carter Hotel, Cleveland.

Oct. 17-21 . . American Society for Metals, Annual Meeting and Metal Exposition & Congress. Trade & Convention Center, Philadelphia.

Oct. 17-21 . . National Safety Council, National Safety Congress. Chicago.

Oct. 19-21 . . National Management Association, Annual Meeting. Dinkler Hotel, Atlanta, Ga.

Oct. 20-22 . . Foundry Equipment Manufacturers Association, Annual Meeting. The Greenbrier, White Sulphur Springs, W. Va.

Oct. 21-22 . . AFS Northwest Regional Foundry Conference. Georgia Hotel, Vancouver, B. C.

Oct. 27-28 . . AFS All Canadian Regional Foundry Conference. Mt. Royal Hotel, Montreal, Que.

Oct. 27-28 . . AFS Purdue Metals Casting Conference. Purdue University, Lafayette, Ind.

Nov. 1-3 . . Investment Casting Institute, Annual Meeting and Design Clinic. Chicago.

How's Business . . .

Going Up . . .

Steel exports hit a three-year high in May—and should reach three million tons for the year. Cold rolled steel exports may be as much as four times that of 1958. Some of this may come back, in the form of imported cars.

Personal income of Americans continued to rise in June, despite declining steel mill payrolls and strikes in the aircraft industry. Based on June, the seasonally adjusted annual rate reached a new record high of $405.8 billion, up $1.1 billion from the May rate. Increase was credited mainly to new income gains for farmers, government employees, and consumer service workers. Personal income for first six months of 1960 reached an annual rate of $400.2 billion—up 5 per cent from previous year.

Industrial material handling equipment manufacturers' bookings increased nearly 28 points in May. Profit squeeze in all types of manufacturing is forcing management to turn to labor-saving equipment offered by material handling equipment makers. —The Material Handling Institute.

Installment debts increased in May at the slowest rate in the past five months. Increase amounted to $323 million during the month. Much of the credit sluggishness was attributed to reduced installment buying of automobiles.

Capital expenditures on plant and plant equipment continue at close to record levels in spite of fact that industrial capacity is generally ample. One explanation is that long-range planners are spending now on modernization when business is slow because prices of new equipment are more competitive. Also, it's easier to install equipment when operations are slow than when going full blast. Foundrymen, please note.

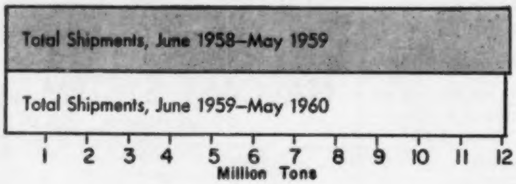
Compact cars will occupy an even bigger share of market in 1961—possibly as much as one-half of the sales. Four new models will enter the "economy" race. New entries will be Dodge Lancer, Pontiac Tempest, Oldsmobile F-85, and Buick Special. This will make a total of ten in the field. About 27 per cent of 1960 sales went to

---

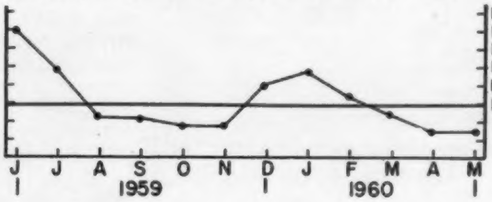
Trends in Metalcastings Shipments

Statistics from Bureau of the Census, U. S. Department of Commerce

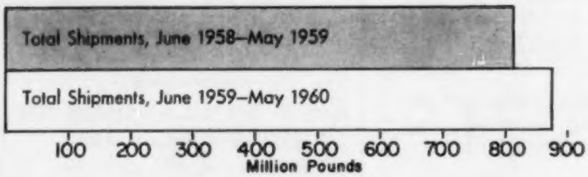
GRAY IRON

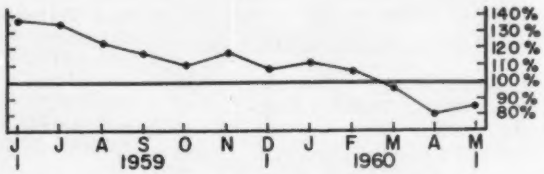


Monthly shipments compared with year ago.

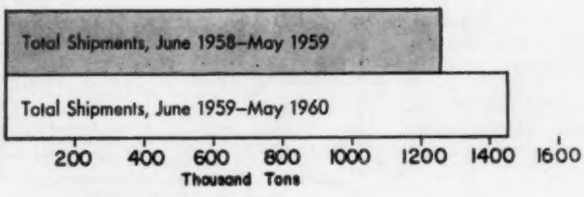


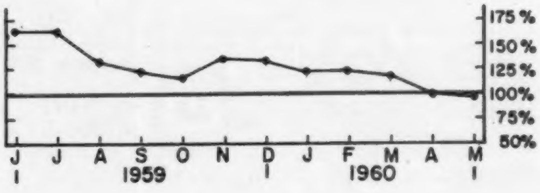
MALLEABLE IRON





STEEL





compacts. Lighter cars mean light engines, smaller parts, less casting tonnage!

Going Down . . .

Unfilled order backlogs of manufacturers dropped in June to the lowest point in 18 months, according to Commerce Department figures. Backlogs stood at $47.5 billion on June 30, down $300 million from May 31. This was seventh consecutive monthly decline. New orders in June dropped 1 per cent below May and inventories rose $200 million. A slow steel industry was heaviest factor in depressing the current status.

Business inventories continued to drop in June but may be bottoming-out, according to the National Association of Purchasing agents. Both production and new orders were stable but prices are softening. Lower prices were reported for steel scrap, large electrical equipment, lumber.

Steel industry operated at slightly less than 51 per cent for month of July—lowest for a non-strike month since 52.7 per cent in May, 1958. By first week in August rate rose to 55 per cent of capacity. Trends in various steelmaking cities were mixed. Some mills were boosting production while others were still banking furnaces. Scrap prices continued to stay down but not much is moving into or out of scrap yards.

Aluminum Company of America has dropped the term "pig" and now sells only ingot. The price of ingot will be reduced to that formerly charged for pig. So ingot users will benefit from a price cut and pig users will get the better quality ingot for the same price.

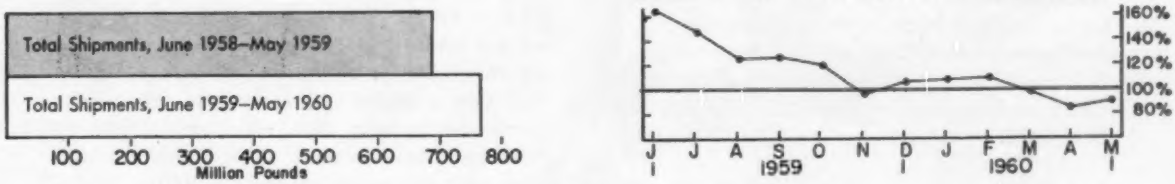
Railroad equipment makers are worrying about a sharp production cutback in second half of 1960. Equipment buying has fallen off since rail traffic has slowed down from original estimates. Railroad car orders slipped to 9794 units for three-month period ending May 31. Compare this with 19,784 ordered in the same period a year ago. Railroad car building may only hit around 50,000 for 1960 (total was 56,414 in 1959). Foundries supplying castings for cars are beginning to feel the pinch.

Metalcasting Shipments . . .

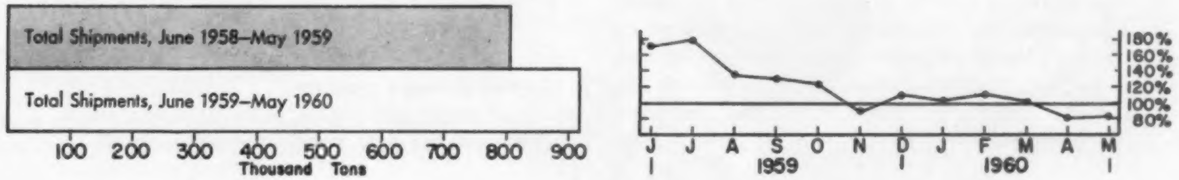
The charts below indicate that a leveling off in the slump of castings shipments occurred during May, 1960. Graphs in right hand columns show that percentages of casting shipments for May, 1960 compare to shipments of May, 1959 as follows: aluminum, 89 per cent; copper, 85 per cent; zinc, 83 per cent; magnesium, 85 per cent; gray iron, 85 per cent; malleable iron, 82 per cent; steel, 94 per cent.

ALUMINUM

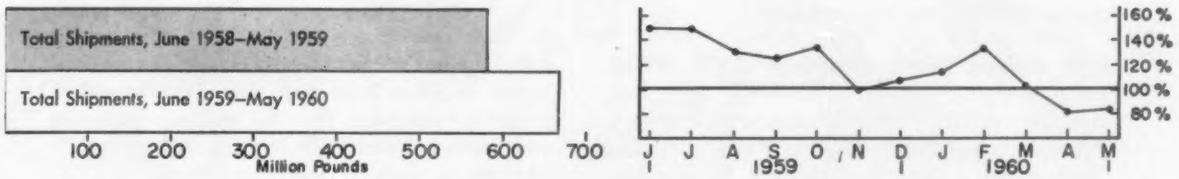
Monthly shipments compared with year ago.



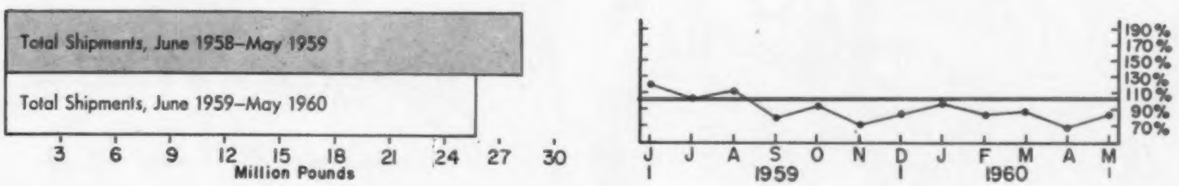
COPPER



ZINC



MAGNESIUM



The Editor's Report . . .

Cellular aluminum . . . is a new one for the foundryman's bag of tricks. A soluble granular compact is infiltrated with molten aluminum. After metal solidifies, the soluble granular component is leached from the composite. A porous aluminum shape remains with density controlled in the range of one-fifth to one-third that of the solid alloy. Individual metal cells are completely interconnected so material is permeable to fluids and gases. Frankford Arsenal metallurgists provided the ingenuity behind this process which permits casting most any shape with cells as small as 100 mesh.

Quotable Quote . . . "Quality is never an accident, but a result of high intentions, genuine effort, intelligent direction, and skillful execution. Quality is built into the casting in every operation."—Carl F. Joseph, Technical Director, Central Foundry Div., GMC.

Graphite cloth . . . is so new that the foundry industry hasn't yet figured out how to use it. The cloth is strong and flexible, and can take temperatures up to 4000 F. May find uses in filtering impurities from non-ferrous metals and collecting dust in hot gases emitted from cupolas, arc furnaces, etc. Graphite cloth is a good electrical conductor and resists attack from most chemicals. Any suggested uses?

Here's a new sand additive . . . "rafter dust" is being added to CO_2 process cores for reduced burn-in and better collapsibility. Now's your chance to use a home-grown crop.

Meat packing houses used to brag . . . about using everything but the squeal in their hog slaughtering departments. Stockham Valves & Fittings, Inc., Birmingham, Ala. rivals this claim in their new brass fittings foundry. All grinding and cut-off wheel dust is caught in their dust-collection system. Then the brass particles are recovered by flotation techniques. After cleaning and drying they are returned for remelting by induction furnaces. Also, gray and malleable iron turnings are brought back from machine shop, washed in a solvent, dried in a rotary hopper, compressed into 9-lb briquettes and comprise 10 per cent of cupola charge.

Try steam . . . to clean out clogged vents in core blow boxes used for CO_2 process cores. Steam also dissolves silicate build-up on walls of boxes and patterns.

Zircon sand . . . at $70 per ton may seem like an expensive molding medium. But when it lets you produce 97 per cent of your steel castings without any need for weld repairing and . . . lets you reduce welders in cleaning room from 11 down to 2, then a second look may be in order. These spectacular benefits have been experienced by American Steel Foundries in their new all-zircon shell mold process at the Indiana Harbor Works. Here's one of the biggest breakthroughs that lets steel castings be made in the foundry (where they should be) and not in the cleaning room (where every hour saved is $20 earned).

Carbon pickup a problem . . . in shell mold casting of steel? Just anneal in an oxidizing atmosphere and this high carbon skin will scale off.

Featherweight casting alloy . . . may be an appropriate title for the new magnesium—14 per cent lithium family developed at Frankford Arsenal. Besides lowering the density of magnesium to 0.050 pounds per cubic inch, lithium changes the crystal structure from close-packed hexagonal to body-centered cubic. Thus the working properties are greatly enhanced. The ratio of ultimate tensile strength to density is a phenomenal 620,000. Space vehicles and ordnance components provide applications for the new alloy.

Jack H Schaum